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Design of Solid-liquid Fine Separator based on PLC Control

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Abstract

In order to adapt to the development of green ecology, this paper designs a flat-plate extrusion solid-liquid separator based on PLC control, innovatively design the filter device and the discharge port device, and add the control core S7-1200PLC. with configuration the network is connected for communication, and the closed-loop control of the electric control system of the whole machine is carried out. The machine has the advantages of good feeding effect, no clogging, PLC intelligent control, simple operation, convenient replacement of wearing parts, high solid-liquid separation rate, and high reliability. The carrier chooses special vehicles to meet the needs of modern urban living quarters, reduce the load of sewage treatment plants in sewage treatment plants, and further reduce pollution to the urban environment.

Keywords

Solid-liquid Separation; PLC; Flat Extrusion; Round Rotor; Solidworks.

1. Introduction

With the rapid development of China's economic construction and the advancement of urbanization, the discharge of domestic sewage in urban residential areas has increased the burden on sewage treatment plants. Even the residue of the septic tank in the residential area will directly flow into the sewage pipe network with the discharge of sewage, resulting in the blockage of the sewage pipe network, resulting in the overflow of sewage everywhere, and the urban sanitation environment is affected[1].

The solid-liquid separation equipment is to collect the residues in the septic tank for centralized treatment, and the filtered sewage is discharged into the sewage pipe network, and finally flows to the sewage treatment plant for unified treatment. This design is only for solid-liquid separation equipment in the fine separation device was designed and optimized. The manure extracted from the septic tank in the living quarters will be coarsely separated to filter out large blocks of dirt or debris, and the filtered dirt will be mixed with water. The sewage will be stirred and mixed with flocculation reaction, and the solid suspended matter in the sewage will flocculate and float up, and the sewage will also be clarified. Then it will flow into the flat-plate sludge dehydrator (solid-liquid fine separator) for solid-liquid fine separation and extrusion dehydration. The discharged water after separation can reach the national three-class water quality standard, and can be directly discharged into the sewer without pollution, while the solid flocculation agglomerates become odorless and harmless organic matter after extrusion dehydration.

Therefore, it is an objective need to design a solid-liquid fine separator suitable for modern urban living quarters. The technical innovation of the solid-liquid fine separator in this paper is mainly:

1) a flat solid-liquid fine separation device;

2) Extrusion device of press unit controlled by servo motor;

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3) The linkage of PLC;

2. Mechanical Separation Technology Problems

Solid-liquid separation devices currently on the market There are mainly the following:

2.1. Centrifugal Dehydrator

Centrifugal sludge dewatering machine is a high-speed rotating equipment, working noise, high energy consumption, shaft and other components prone to problems, frequent maintenance and high cost.

2.2. Plate Frame Dehydrator

The plate-frame dehydrator is a filtering equipment with intermittent operation. It covers a large area and cannot achieve continuous mud treatment. The equipment is open and the working environment is poor. In addition, due to the large number of auxiliary equipment of the plate-frame dehydrator, the failure rate of the later dehydration treatment is relatively high.

2.3. Screw Dryer

At present, the screw-type dehydrator is widely used in the market, but it is not suitable for the separation and treatment of metal sludge. Under the condition of normal washing, due to the excessive banded fibers in the sludge, the spiral shaft is wound, so that the spiral shaft becomes a cylinder, which cannot pull the sludge forward, and it is difficult to form internal pressure, resulting in small amount of sludge and high water content[2].

In order to solve the above problems of the same type of dehydrator, it is necessary to design a dehydrator with low operating cost, good quiet performance, small footprint, high degree of automation, low moisture content of solid slag, modular assembly and easy maintenance and replacement of parts.

3. Working Principle and Structure

3.1. Overall Structure and Working Process

Solid-liquid fine separator based on Solidworks 3D software design, the overall structure is shown in Fig.1.

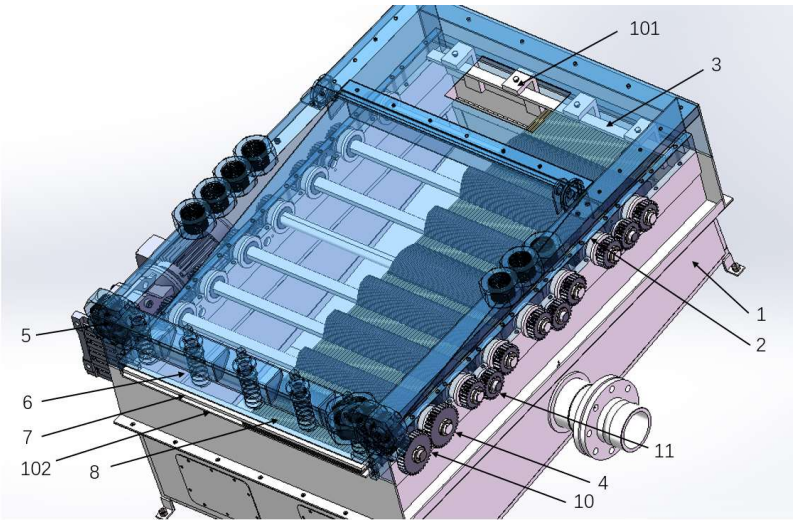

Fig.1 Structure diagram of solid-liquid separator

1-shell; 2-circular rotor; 3-Pressing plate; 4-Shaft; 5-Standing pole; 6-spring; 7-support block; 8-guide plate; 9-Gears; 10-first hinge shaft; 11-intermediary wheel; 101-feed port; 102-outlet;

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3.2. Overall Structure and Working Process

A flat-plate solid-liquid fine separation device includes a shell. One end of the shell is provided with an inlet port, and the other end is provided with an outlet port. In addition, the shell is also provided with a load-bearing unit, a transfer unit and a pressing unit. The method for realizing the solid-liquid fine separation is as follows : the material enters from the feed port, and supports the material through the bearing unit ; the feeding unit comprises a plurality of rotating shafts, and each rotating shaft is arranged with a plurality of circular rotors, and the material on the bearing element is transferred from the feed end to the discharge end through the rotation of the circular rotor ; the extrusion of the solid-liquid mixture is achieved by a pressing unit, thereby separating the solid residue from the water[3]. The flow chart is shown in Fig.2.

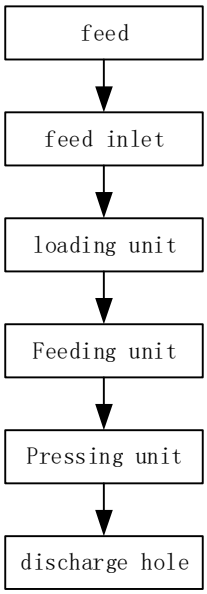

Fig.2 Flow chart of solid-liquid separation

4. Innovative Design of Feeding Unit

4.1. Forced Filter Design

In the flat plate solid-liquid separation device, the water in the mixture is filtered through the process gap between the guide plate and the circular rotor, but the macromolecules treated by flocculation are difficult to pass, thus ensuring the cleanliness of the effluent. Since the circular rotor in the process of rotation, can fully achieve meshing, that is, no intermittent tangent contact, and the tangent point is unique, continuous contact, to ensure no material omissions[4]; therefore, water is separated from the solid treatment by the extrusion of the circular rotor and the press plate.

4.2. Gapless Tangent Contact Rotor Design

The rotor design includes a plurality of horizontal shafts arranged side by side in the lower chamber. Each shaft is arranged in parallel with a plurality of circular rotors. The number of circular rotors on each shaft is the same as the number of gaps in the bearing element. The circular rotor is set in its corresponding gap, and the thickness of the circular rotor is the same as its corresponding gap width. The radius of the circular rotor is greater than the distance from the shaft to the top surface of the bearing element. In the same gap, the outer surfaces of each adjacent two rotors are in contact, and the material on the bearing element is transferred from the feed end to the discharge end through the rotation of the circular rotor.

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The matching accuracy and assembly process requirements between the circular rotors are very high. The two rotors should achieve no gap tangent contact, and the tangent point is unique during the operation, so as to ensure that no material is missed, as shown in Fig.3.

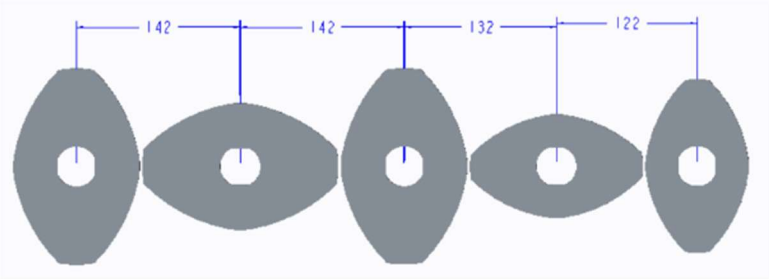

Fig.3 Fit of multiple circular rotors

4.3. Finite Element Analysis of Single Circular Rotor

The structural parameters of a single circular rotor are as follows: the inner circle diameter of the ring is 17.5mm, the outermost circle diameter is 190mm, and the outermost tangent circle diameter of the circular rotor matched with another is 110mm. The material of the circular rotor is 304 stainless steel, and its yield strength is 205Mpa. Considering the life of the equipment and the stability of the work, the safety factor is 2, and the allowable stress is about 137Mpa. Elastic modulus E=2.1×1011, Poisson's ratio μ=0.3.

According to the actual working conditions, take a single circular rotor radial compression P1=0.02Mpa, axial compression P2=0.01Mpa. The circular rotor model is meshed by tetrahedral elements, and the mesh size is 0.001mm. According to the fixed condition of the circular rotor, various loads and constraints are applied to the finite element model of the circular rotor, and the stress distribution of the circular rotor can be calculated.

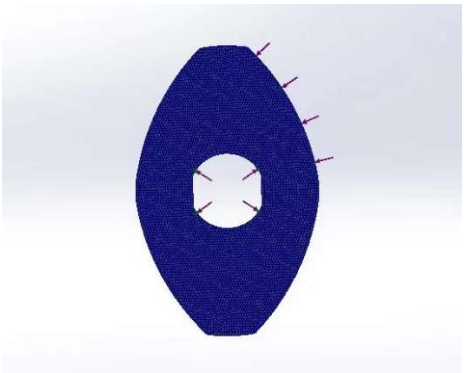

Fig.4 Circular rotor gridding

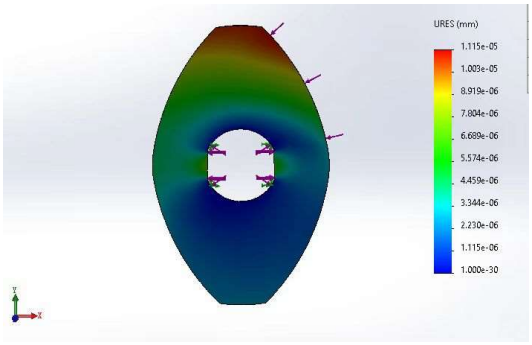

Fig.5 Stress distribution of a single circular rotor

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It can be seen from Fig.5 that the maximum stress is located at the contact between the circular rotor and the solid slag. The maximum variable of the circular rotor is 0.852 mm, and the maximum stress is 105.32 MPa, which is less than its allowable stress of 137 MPa and meets the strength requirements.

5. Design of Pressing Unit

5.1. Design of Electronically Controlled Unloading Device

The servo motor amplifies the torque through a planetary reducer and is connected to a T-screw through a coupling. The forward, reverse and rotation speed of the motor are controlled by PLC. The rotation of the T-screw makes the spring plate move along the guide column while compressing the spring. As the spring is compressed, the pressure of the spring on the conical discharge baffle also increases, thereby increasing the extrusion pressure on the material outlet, and ultimately achieving the purpose of controlling and reducing the moisture content of the material[5]. A moisture content detection and pressure sensor is installed at the discharge plate, and the data measured by the sensor is transmitted to the PLC. Through data conversion, a closed-loop control is finally formed with the operation of the motor, as shown in Fig.6.

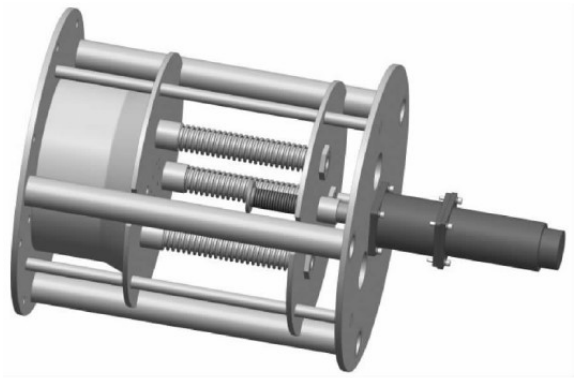

Fig.6 Electric discharge device diagram

5.2. Design of Circuit Control System based on PLC

Electronic control system uses: Siemens S7-1200PLC programmable controller, Siemens S7-1200KTP industrial color touch screen, D75 switching power supply, A / D converter. Drive system uses: 86 full-closed-loop high-speed servo stepper motor, two-stage planetary gear reducer, 5KW variable frequency motor. The sensor system uses: pressure sensor. The electronic control system of full closed-loop control is composed of the above control parts, which realizes the one-click start and stop of the whole machine, the full color liquid crystal control interface, and the unattended operation can be realized after setting the target moisture content. The system sets both automatic mode and manual mode, which can be selected according to the field situation. The PLC control system integrates the control of each device into the centralized control of the PLC intelligent control system. At the same time, the control logic is simpler and the devices are linked and guaranteed to each other, which greatly improves the reliability and maintainability of the whole machine.

6. Conclusion

In this paper, a set of solid-liquid fine separator based on PLC control is designed to realize automatic filtration of industrial sewage. The S7-1200 PLC control system of Siemens is used to control each module, and the automatic control process of sewage treatment is realized. And through the industrial Ethernet and central control room for information communication, to

achieve real-time detection of data upload, and equipped with configuration WinCC software real-time display. The new solid-liquid fine separator uses a new flat sludge dewatering machine to dewater the flocculated sewage, compared with other similar products, the comprehensive treatment capacity is doubled.

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