Sludge Desilting Treatment Device for Urban Pavement Sewer

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Abstract. The purpose of this project is to design a sludge cleaning device with wider applicability, simpler operation and better effect, so as to fill the vacancy of sludge cleaning device in domestic small and medium-sized sewer. These devices are not widely used in our country because of their high cost, not suitable for small and medium-sized pipelines and need to be put into wells manually. In this project, a small and medium road sludge cleaning device is designed to solve these problems. The device only needs one person to control, and the whole dredging process is completed by the device independently, which makes cleaning faster and simpler, and has good environmental adaptability.

Keywords: Urban pollution, sludge accumulation, pipeline cleaning, miniaturization, mechanization.

1. Introduction
This scheme envisages the design of a semi-automatic control sludge cleaning cart operated by a cleaner. The main design scheme is as follows: movable locking frame module, well cover lifting module, sludge cleaning module, sludge collection module and intelligent control panel module. The well cover lifting module is mainly divided into lifting module and supporting rod expansion module; sludge cleaning module is mainly divided into crank slider support module and lifting sludge collection expansion module; sludge collection module mainly includes sludge pump and sludge collection tank.

2. Research background
In recent ten years, the sludge treatment equipment widely used abroad mainly includes: high pressure water dredging equipment, flexible shaft dredging equipment and sludge suction equipment. There are some problems in these equipments, such as high cost, single treatment method, manual operation in the well and so on. And there is no professional treatment equipment for the sludge of rainwater sedimentation tank, so it can not be widely used in China.

In China, due to the vast land area and dense population, it is a very heavy task to clean the urban rainwater sedimentation tank regularly. As we all know, the main components of sludge in rainwater sedimentation tank are rotten leaves, road dust and so on, and many pollutants on the road surface are also enriched in the sludge. The existing treatment methods in China are mainly manual treatment,
sludge pump treatment and grab truck treatment, which will cause environmental pollution and waste of a lot of resources in the process of treatment.

3. Overall scenario

3.1. Introduction to the working process of the device

The overall working process of the device is as follows: firstly, the cleaning personnel push the device to the working position, step on the locking structure of four wheels to make the device unable to move. Secondly, manually shake the handle of the lifting module of the well cover to make the device reach the working position through the hole of the well cover. Then, the cleaning personnel need to manually support the lifting module of the well cover, so that the device can hook the well cover from the bottom of the well cover Lift the well cover by shaking the handle. If the sludge in the well has dried up, in order to facilitate the sludge cleaning, a small amount of water can be injected into the well to turn the dried sludge into slime. After the well cover is hoisted, the staff issues an order on the control panel to lower the sludge cleaning device to the working position. The fixed module of the device is first deployed. After the expansion plate structure meets the requirements of the pipe wall pressure value, the expansion plate structure at the bottom begins to expand to the appropriate position. Then, the blade at the bottom is installed to start to rotate and scrape the sludge. The sludge pump can pump the sludge collected below to the installation site In the sludge collection tank. After the collection of the device is completed, the cleaning personnel will issue an order on the control panel, and the sludge cleaning device will be withdrawn upward to complete the work.

![Figure 1 overall scenario](image)

3.2. Frame module design

As the main body and load-bearing module of the whole device, the overall shape refers to the relevant structure of the trolley, which can be operated by one person. The upper part of the car body is mainly divided into intelligent control module and sludge collection tank load-bearing module, with reasonable layout. Under the bearing plate are the suspended mechanism of the sludge cleaning module in the center and the hoisting module of the well cover on the left side. Setting the lifting module on the left side can make the well cover not hang in the center of the sewer pipe after lifting, which will not affect the normal operation of the sludge cleaning device.

Four pairs of moving wheels are designed at the bottom of the car body. The first two pairs are driving wheels and the last two pairs are driven wheels, which are convenient for operators to push. A shock absorber spring is also designed at the joint above the wheel, so that the frame can adapt to different road conditions. Each pair of wheels is designed with a self-locking structure of the foot, which is similar to the self-locking structure of the baby carriage. The wheel self-locking structure is designed to stabilize the body when the sludge cleaning device is working, so that the body will not shake at will and affect the work of the working device. The triangular reinforcement structure is adopted in many parts of the whole body, with less material but high strength.
3.3. **Hoisting module design of well cover**

The traditional opening method is to pry the inner wall of the well cover and the hook hole manually by using the pick, pry bar, sledge hammer and the hook hole of the manhole cover by hand, so as to realize the purpose of removing the well cover from the well. However, due to the heavy weight of the well cover, manual lifting of the well cover is not only time-consuming, but also inefficient. Especially in the harsh environment for a long time, the soil between the well cover and the kiln edge will be filled and compacted, which makes it more difficult to open the well cover.

Therefore, this project designs a new hoisting device for well cover. The lifting module of well cover is of bundle shape. The design idea of the device mainly refers to the deployment and recovery of the umbrella, and designs a three-link mechanism with four links per rotation of 90 degrees. When not in use, the whole device is in a retracted state and is suspended on the left side of the vehicle body. When using, the cleaning personnel need to first align the device with the opening of the well cover through the manual rocker, lower most of the structure of the device, and then manually expand the device. Due to the cone-shaped limiting device at the bottom of the device, the bottom rod of the three connecting rods can only be opened by 90° from vertical to horizontal state, sticking the well cover from the inside, reversing the hook with four claws and hooking the well from the inside. Finally, the device moves upward through the hand rocker. At the same time, the well cover is lifted by the lifting device along with the reverse hook claw, and moves to the left side of the device, and the well cover is opened.

![Figure 2](image_url)

**Figure 2** Two states of manhole cover lifting module

3.4. **Design of sludge cleaning module**

The sludge cleaning module is the main work module of the whole device, which is installed in the center of the whole frame, and the device is lifted and lowered by the automatic suspension mechanism above. Before working, the cleaning personnel need to align the device roughly with the outlet of the sewer pipe. The device is divided into two modules: fixed module and cleaning module.

![Figure 3](image_url)

**Figure 3** Sludge cleaning device

3.4.1. **Device fixed module design.** The fixed module of sludge cleaning device is designed by two layers of crank slider mechanism, a total of six directions of crank slider mechanism are designed as the fixed module of the device.

The sliding bars on the upper and lower floors can rotate horizontally due to the limit device. The six groups of crank slider mechanisms can only rotate clockwise. The structural design of crank slider is mainly to adapt to the urban sewer pipe orifice with different diameters. Through the rotation of the
crank slider structure, the distance from the farthest point of the device to the center of the device can be changed, so as to adapt to different sizes. When the device starts to work, the crank slider structure shrinks inward, making the overall device in the minimum diameter state. After the device reaches the working position, the internal motor controls six groups of crank slider mechanisms to extend outward. The top of the sliding rod is designed with rough contact surfaces in three directions, and a pressure-sensitive device is designed inside, which can sense the pressure value between the top and the sewer pipe wall. When the pressure value reaches the specified requirements, the device will be locked and the suspended working module will be fixed by pressure and friction.

When the work is finished, the cleaning personnel will issue an order on the operation panel, and the six groups of crank slider mechanism will start to shrink inward. After the contraction to the minimum state, the electric lifting module will lift the whole device upward to complete the whole working process.

3.4.2. Design of expansion board cleaning module. The expansion plate cleaning module is located under the fixed device and enters the rainwater sedimentation tank with the extension of the lifting rope. Due to the large space at the bottom of the rainwater sedimentation tank, the central expansion module will expand after the sludge cleaning module enters the bottom. The expansion plate will move downward along the slope of the hexagonal prism in the center until the whole surface area of the device extends to the size of the rainwater sedimentation tank. A group of inclined rotating blades are arranged under each expansion board, and the interval distance is set in the blades, and the side fixing device is fixed when the device works.

![Figure 4 Schematic diagram of blade at the bottom of sludge cleaning](image)

The cleaning module of the device mainly realizes a preliminary scraping of the sludge at the bottom through the continuous rotation and cutting of the blade under the constant action of gravity during the falling process of the device. Because there is a long and thin strip gap on the expansion plate, the bottom blade is continuously rotated and scraped, and the expansion plate is continuously downward under the action of gravity, so that the sludge in the sewer pipe can enter the upper part of the expansion plate through a small slot after being scraped by the blade. There is a slope inside the six expansion plates. The outside of the inclined plane is high, and the inside is low. The sludge entering the expansion plate will enter the inside of the hexagonal prism along the slope. Along with the internal water pipe, the sludge pump is pumped into the sludge collection tank above the frame to realize the collection. The sludge with poor fluidity will be temporarily left on the top of the expansion plate. There is a plate wall around the expansion plate, which can be used as a temporary collection place for the sludge with poor liquidity. Finally, this part of sludge will be treated with the lifting of the device.

When the device is working, the rotating module drives the bottom of the device to rotate, and at the same time, the pressure is applied from top to bottom to make the bottom sludge enter the temporary storage space along the clearance under the dual effects of blade scraping and pressure. Then, the sludge is transferred from the inner part of the hexagonal prism to the storage device by the sludge pump. Through continuous scraping of sludge, the sludge in the rainwater sedimentation tank can be cleaned. The floating ball liquid level meter is also installed in the sludge collection device,
which can reflect the amount of sludge in the sludge collection device on the control panel at any time, so as to facilitate the staff to monitor the device in real time and avoid overload of the sludge collection device.

3.5. **Sludge storage module**

The sludge collection module is mainly divided into two parts: sludge collection tank and sludge pump. The sludge collection tank is placed above the bearing platform on the right side of the device, which can balance the gravity generated by the suspension device of the left well cover. A coarse water pipe is trained between the lower part of the collection box and the hexagonal platform of the sludge cleaning device, and the upper part is connected with the sludge pump. The sludge collected inside the hexagonal prism is pumped into the collection tank by the sludge pump in

4. **Innovation and project characteristics**

This project mainly includes the following innovations:

1. The miniaturization design of desilting device is put forward, which is applied to small and medium-sized sewer pipes;
2. Lifting sludge collecting plate is suitable for different diameter sewer pipes;
3. The crank slider mechanism is used as the fixed module to make the fixation more reliable;
4. Two kinds of sludge collection methods are adopted, which are suitable for sewer pipes with different silt texture.

5. **Conclusions**

This project designs a small and medium-sized sewage pipeline sludge cleaning device with wider applicability, simpler operation and better effect, so as to fill the vacancy of domestic small and medium-sized sewage pipeline sludge cleaning device. The overall design of the device is reasonable, innovative and high cleaning efficiency. The whole desilting process is completed by the device independently. The cleaning is faster, the operation is simpler and has good environmental adaptability. Therefore, the device has broad application prospects.

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