Research and Application of an Automatic Clam Collecting Device

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Abstract. To collect clams automatically and effectively on coastal beach, an automatic clam collecting device was designed. The device consists of a connecting device, a shovelling device, a conveying device, and a filtering device. The mechanical device is designed based on some of the presented devices, such as a blade with slope, a pipelined conveyor belt, planar linkage mechanisms and a ski mechanism. The connecting device is connected to the device body by bolts. The shovelling device adopts a blade with slope, which can reduce the resistance between sandy soil and the device. The transmission device adopts a conveyor belt with a two-stage reducer, which can effectively control the speed of the transmission and avoid the splash of mud. A mesh structure is used for soil filtering, which is designed with a certain slope, thus sandy soil and other impurities fall from the mesh for its own weight. The designed device for clam collecting will improve efficiency and decrease cost effectively.

1 Introduction

The development of shellfish collecting machine has more than 70 years of history. There have been many kinds of shellfish catching machines used to seed, shallow sea resources and collect shellfish and dead shells. A number of collecting machines have been analysed, which mainly have the following characteristics [1]. 1) Collecting clams, mussels, oysters and thin shell of vermiculite. 2) Working on tidal flats or collecting shellfish in shallow sea. 3) Can collect various kinds of shellfish on the surface of the mud, sand, sand or gravel. 4) Collecting machine is divided into types of semi mechanical devices, which are pushed by hand and types of devices with different degree of mechanization.

FletcherHanks catching machines are widely used in many countries for seashell collecting, which is improved on different purposes based on the structure of Mya arenaria Linnaean's collecting machine [2]. In recent years, the design of a novel clam collecting machine adopting mechanical lifting mechanism has been completed, which has been manufactured and tested in Virginia State.

A type of hydraulic collecting machine has been developed in Canada [3], which is pushed by hand. While the machine is working normally, a man pushes the machine forward slowly, and the other person collects the clam in the ditch. This machine is especially suitable for operation on gravel or shallow water.

A high efficiency hydraulic clam collecting machine was developed in the UK [4]. Sediment and clams on the tidal flat is dug up by high pressure water, which is spurted from high pressure water pump. And another auxiliary pump sucks gravel, clams and other impurities in to the shipboard. At last, the young shellfishes and other impurities are filtered out through the metal net.

Marine fishery headquarters and Rudong County [5] jointly developed an automatic clam collecting device. They do a test in a high yield area where hourly clam yield can reached 900 kg to 1000 kg. Although in theory this device is reasonable, the actual use has a large gap with the imagination. Because the machine and the ship are not matching, and the operation is not convenient, so the machine still needs to be improved. On this basis, Yellow Sea Fisheries Research Institute [6] developed the type of wcs-6 shellfish collecting machine. Experiments were carried out in the Laizhou Bay. Derived from the experiments, the device can capture clams about 150-200 kg per hour, and the damage rate is relatively low, which is not more than 4-5%.

Overall, the current situation is that clam collection of the demand for labor is relatively large with high cost. So in view of the current problems, a collection device for clams in beach is designed.

2 Innovative Design

The innovative device adopts the principle of similar ploughing device to dig the clams on the beach. Under the driving of the motor, clams and sediment which have been spaded are uplifted through the role of the common conveyor and speed reducer [7]. The final collecting of clam is completed through the implementation of the sediment filter.

Since the device is required to work on the beach, it cannot adopt ordinary wheels. Therefore, the device adopts track wheel, which can increase the contact area

with sand [8]. By adopting this design, car is not easy to fall into the sediment, and normal running of the car on the surface of the sand can be ensured. In addition, the design of the support of the device adopts sliding plate structure, which can reduces drag and saves the cost of the device. The significance of this device is that it can liberate the dependence on labor and accelerate efficiency of collection.

Because of the innovative design mentioned in this paper, the device has the following main advantages.

- It can achieve the goal of massive cultivation, liberate the dependence on the labor, and accelerate the efficiency of the clams' collection.
- It can save the resource efficiently.
- It can promote the development of aquaculture.

3 The structure and working principle of the collecting device

3.1 Device structure

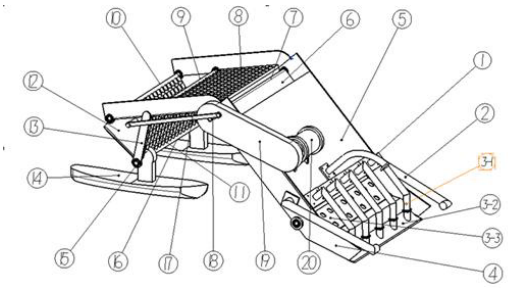

Figure 1. Device structure diagram.

The machine is consisted of main connecting support 1, connecting support 2 on two sides, blade assembly 3, blade linkage 3-1, blade 3-2, filter plate with holes 3-3, baffles on both sides 4, upper baffle 5, transmission belt 6, roll bar 7, filter screen 8, mesh swash-plate at front 9, mesh swash-plate at back 10, V-shape cage 11, fan-shaped rocker 12, connecting support 13, ship form support 14, bearing 15 the roll bar under the V-shape cage 16, connecting rod 17, crank 18, secondary expansion helical gear reducer 19, motor 20, transmission belt's roll bar bellow.

The device is connected with the body of tractor through connecting support 1 and connecting support 2 on two sides. When the tractor is moving, it drives clams collecting device to move on the beach through connecting support 1 and connecting support 2 on two sides. The device adopted support, which is ship type. Small contact area with sediment and small sliding resistance can be achieved by this way.

The device has blade assembly 3 at front. The blade assembly is consisted of blade linkage 3-1, blade 3-2 and filter plate with holes 3-3. One side of blade linkage 3-1 is connected with the shank of blade 3-2 by bolts. Another side of blade linkage 3-1 is fixed on upper baffle 5. The blade 3-2 has some curves.

The drive assembly is consisted of motor 22, big belt-pulley 21, small belt-pulley 19, belt 20, roll bar 7, transmission belt 6 and baffle 5. The motor 22 is fixed on baffle 5. The power of motor 22 is directly output on big belt-pulley 21.

One side of roll bar 7 is connected with crank 18 by spline and drives crank 18 to rotate around its axle. Crank 18 is connected with connecting rod 17 by bears and pins. Connecting rod 17 covers around cylindrical shank of fan-shaped rocker 12 by bears.

3.2 Shovel device design

As the device is moving, the blade 3-2 will dig and uplift sediment, it will also dredge the clams out. While the device keeps moving, the sediment and clams will be uplifted by the blade 3-2, and bilateral baffles 4 keep the sediment and clams in the device from moving out. After the sediment and clams move through the blade 3-2 with curves, they will be conveyed to filter plate with holes 3-3 and some of the sediment will be filtered.

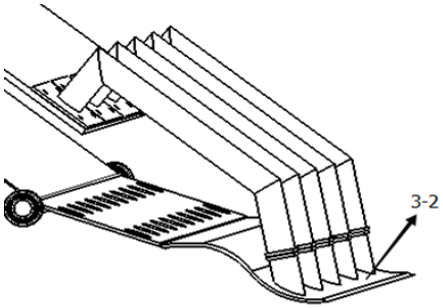

Figure 2. Schematic diagram of shovel.

3.3 Sand filter design

Big belt-pulley output power on small belt-pulley 19 by belt 20 and drives small belt-pulley to rotate. The small belt-pulley is connected with roll bar 7 by spline. The rotation of small belt-pulley drives the rotation of roll bar 7. Roll bar 7 nested on baffle 4 by bear. The transmission belt 6 is to transmit clams and sediment.

There is a round hole at V-shaped bottom of fan-shaped rocker 12. The round hole covers around V-shape cage 16 by bears [9]. Connecting rob 17 drives fan-shaped rocker 12 swing around V-shape cage 16. The swing can shake off the sediment.

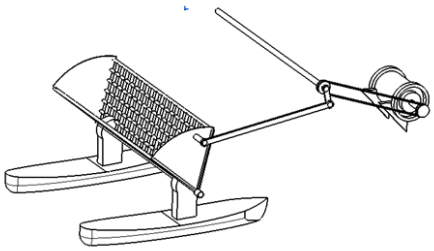

Figure 3. Schematic diagram of sand filter.

When the transmission belt 6 transmits clams and sediment to filter screen 8, the filter screen will filter the sediment. Clams will fall into V-shape cage 11. There are baffles on both sides 4 over the V-shape cage 11, which are designed to prevent clams from getting out. Mesh swash-plate at front 9, mesh swash-plate at back 10 are

fixed in the hole of baffle 4. They can also prevent clams from getting out.

4 Detail design

4.1 Shovel device

Shovelling blade is made of wear resistance and impact resistance steel. It needs to be heat-treated. Because the friction between the shovelling blade and sandy soil is pretty heavy and always results in abrasion of the blade.

4.1.1 Resistance calculation of the blade

Literature [10] proposed an equation for the calculation of shovelling blade's cutting resistance, which can be used for the resistance calculation of this paper. The equation is listed as follows.

$$K_b = 10^{-6}\frac{p_0}{bh}(MPa) \quad (1)$$

Where P_0 is the cutting resistance on shovelling blade (N); b is the width of shovelling blade (m); h is the cutting depth (m).

We can get cutting force of the blade is:

$$P_0 = K_b l_1 h_{cp} \times 10^6 \quad (2)$$

Where K_b is cutting rate resistance (MPa); l_1 is the length of blade's cutting edge (m); h_{cp} is average cutting thickness (m).

Now combine the dimension parameter, we can get the cutting resistance, which is 2.5 kN.

4.2 Power train design

The driving power of the device comes from the engine of the tractor which drives the tractor to move ahead. The rotational speed of the tractor is too high to be directly used for device. Therefore a helical gear reducer is designed to decrease the input speed of the device. The sketch drawing of the two-stage reducer is illustrated in Fig. 4.

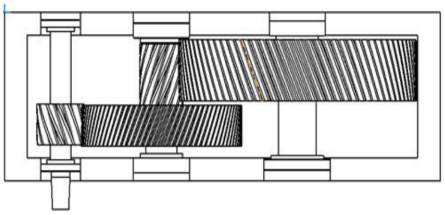

Figure 4. Schematic diagram of shovel.

4.2.1 Design parameter

According to the working condition of the device, the parameters of the transmission system of the device should be well designed in advance. Considering the friction of sandy soil and shovel structure, the parameters are listed in the following table.

Under the working condition of continuous unidirectional rotation, the load of the device has fluctuation. Therefore, Allowable error of the conveyer belt's working speed is between -6% and +6%.

Table 1. Value of parameters.

Parameter	Value
Conveyer belt's Working pull F (N)/N	2800
Conveyer belt's working speed V/m/s	1.5
Drum's diameter D/mm	320

4.2.2 Transmission scheme

Due to the vibration when machine is working, the material of conveyor belt should be selected according to the effect of vibration reduction. Reducer adopted two-stage expanded helical gear reducer [12]. But the Gear and bearing is not on the same line, so the shaft should have relatively large stiffness. In addition, the layout of the high speed gear also have requirements. In order to reduce the phenomenon of the uneven distribution of loading, so the high speed gear is required to be put away from input terminal.

According to the requirements, the transmission scheme are as follows.

- Outer transmission is V-belt drive.
- Reducer is two-stage expanded helical gear reducer.
- Schematic diagram is shown as follows.

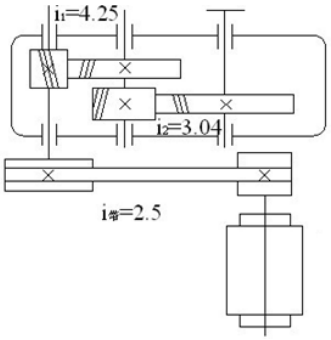

Figure 5. Diagram of two stage reducer.

4.3 Calibration for sand filter

This paper adopts the planar linkage mechanism as sand filter device. This planar linkage has a variety of applications. Advantages are as follows.

- Between the various components of the device is a surface contact, which can withstand greater load. Also, this way is very suitable for lubrication, which reduce wear and tear between components of the device effectively.
- Because the device adopts the plane contact. Therefore, the device is relatively easy to be manufactured and processed. Also, the device can get high accuracy.

- The device can change the length of each bar, so as to realize a variety of motion.

4.4 Design and calculation of V-belt drive

4.4.1 The choice of V-belt

This device is used for clam collecting in shallow beach, so applicable load and the diameter of the belt pulley should not be too large. According to the design requirement and users' feedback, ordinary V-belt was chose. The reason is that the common V belt is cord structure, which can resist tension.

4.4.2 Design of pulley

Because the power of the motor is low, so aluminium was chosen as the material of pulley. In order to make the belt wheel do not shake in the drive, the pulley needs to be corrected by a dynamic balance way. Based on comprehensive thinking, we decided to choose wheel-spoke pulley. Because it fits in multiple environment. In high rational speed condition, we chose cast steel. In low power condition, we chose cast aluminium.

4.4.3 Contented conditions needed

To prevent relative displacement when pulley is working, the peripheral force is needed to be ensure that it is smaller than maximum effective tension. To extend the life of V-belt, we need to ensure that belt's maximum stress is smaller than its allowable stress.

5 Program benefits

The plan adopted crank-rocker mechanism to achieve the swing of V-shape cage and high degree of filtration of sediment. The power of crank-rocker mechanism and transmission belt comes from roll bar, which can ensure that crank-rocker mechanism and transmission belt rotate in same speed.

There are two mesh swash-plates, which is installed on the top of the v shape cage. As the V-shape cage is swing, mesh swash-plate at front and mesh swash-plate at back hold contact with the V-shaped hole of the V-shape cage from beginning to end, so there will be no spaces between V-shape cage and filter screen.

This device adopted sliding plate structure as the brace to increase the measure of support surface and prevent it from sliding into the sediment.

It adopted two-stage reducer, which can control the rate easily.

6 Conclusion

The invention is applicable to the large-scale acquisition of mudflat shellfish such as clams with the high degree of automation, low cost, high efficiency, and low leakage rate of mining. The device can not only effectively dug out clams and other shellfish, transport clams and other shellfish, but also can greatly reduce the resistance, so as to realize the collection of the clam of tidal flats.

Also the device has some problems, because of the clam survival environment will change, and the device can realize the acquisition of clams on the tidal flats, unable to adapt to some other environment, so the device still needs to be improved. In the future, the device should be improved in this direction, the design of a waterproof device may be better to adapt to changes in the environment.

Acknowledgment

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