

Original Article

Research on Marine Garbage Collection Ship Model for Ecological Restoration

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Abstract - Due to the increasing range of human activities, the marine environment has been gradually destroyed, and there is a large amount of marine garbage in the ocean. We designed a marine garbage collection ship, mainly including a hull part, walking unit, garbage dumping unit, control unit, garbage gathering unit, garbage conveying unit, conveyor belt bonded garbage cleaning unit, and garbage identification and positioning unit. The floating garbage on the water surface is gathered at the conveying unit through the garbage gathering unit. The toothed conveyor belt in the conveying unit conveys the garbage to the garbage storage box to realize efficient garbage collection. The conveyor belt bonding garbage cleaning unit can separate the garbage bonded to the conveyor belt to ensure the cleaning of the conveyor belt so as to achieve continuous and efficient work. The garbage dumping unit can realize automatic garbage dumping and improve the efficiency of garbage cleaning. Adding tools such as Open CV and GPS, with garbage identification and hull positioning functions, can efficiently remove marine garbage and reduce marine garbage pollution.

Keywords - Marine garbage collection, Toothed conveyor belt, Shearing fork mechanism, Conveyor belt bonded waste cleaning unit, Garbage identification.

1. Introduction

In recent years, due to excessive exploitation by human beings, the marine environment has been destroyed, the ecosystem continues to deteriorate, and a large amount of marine garbage has been produced, resulting in a sharp decline in biodiversity [1-6]. These marine wastes affect the marine landscape, threaten navigation safety, and negatively affect the ocean in many aspects. Marine garbage mainly consists of floating garbage on the sea surface, which is of great variety and difficult to salvage [7-9]. Nowadays, people also attach great importance to controlling marine garbage and plastic pollution. However, at present, marine garbage cleaning generally adopts the way of artificial salvage, which is time-consuming and labour-intensive. However, the existing surface garbage collection ships have some problems in the garbage collection, such as low intelligence degree and omissions, especially the floating garbage on the surface having a high water content, which is easy to bind to the conveyor belt. There is an urgent need for a new and efficient device to clean up rubbish [10-20].

2. Overall Scheme Design

Through a large number of materials learning and research, the overall structure of the marine garbage collection ship designed is shown in Figure 1, which is

mainly composed of the following parts: hull part 1, walking unit 2, garbage dumping unit 3, the control unit 4, garbage collection unit 5, garbage conveying unit 6, conveyor belt bonded garbage cleaning unit 7, and garbage identification and positioning unit 8.

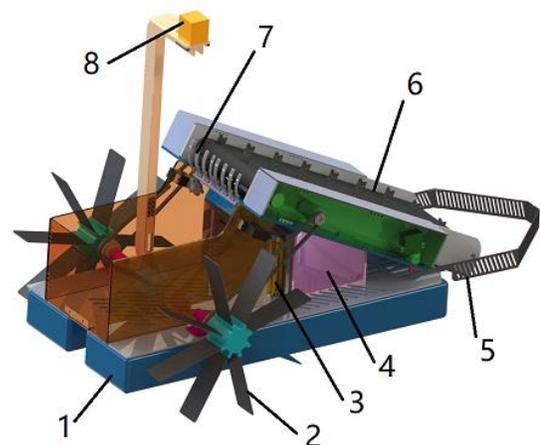


Fig. 1 Overall structure of marine garbage collection ship

The hull is made up of a floating plate, which generates buoyancy, and a main deck, which is mounted on the plate, while the hull mainly serves as a load-bearing function, keeping the rest of the marine garbage collection ship afloat.



The walking unit is mainly composed of a water wheel paddle, mounting seat, driving motor and synchronous belt. The hull's forward, backward and turning can be realized by fluctuating water surface of the propeller. The garbage dumping unit is mainly composed of a shearing fork mechanism, through which the garbage can be automatically pushed out of the garbage storage box, which can improve the low efficiency of manual dumping of garbage. The control unit includes a control board, battery and other modules to realize the control functions of the motor, steering gear and camera on the garbage collection ship. The garbage collection unit is mainly composed of a pair of forward oars, which can be opened to cooperate with the forward motion of the hull to gather garbage at the conveying unit and improve the efficiency of garbage collection. The garbage conveying unit is mainly composed of a toothed conveyor belt and motor, which transport garbage from the water surface to the garbage storage box. The conveyor belt bonded garbage cleaning unit is mainly used to clean the garbage bonded on the tooth conveyor belt, to realize the separation of easily bonded garbage and the tooth conveyor belt. The garbage identification and location unit has a built-in camera and GPS positioning module to identify surface garbage and hull positioning automatically.

3. The Working Principle of Garbage Collection Ship

3.1. Garbage Collection Unit

When the garbage collection ship is in the working state of garbage collection, the forward oars 51 and 52 are in the open state, as shown in Figure 2 below. As the ship slowly moves forward, the forward oars can gather floating garbage on the surface of a large range to the garbage conveying unit, increasing the efficiency of garbage collection. When the hull is not in garbage collection operation, the forward oars are tightened in front of the hull, as shown in Figure 3, to reduce driving drag and save energy. The forward oars are provided with strip-through holes to reduce further the drag of the forward hull and the forward oars, as shown in Figure 4 below. The forward oars 51 and 52 are respectively driven by the steering engines 54 and 53 to realize the function of garbage collection.

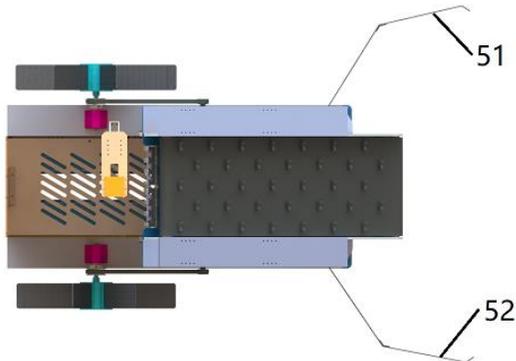


Fig. 2 Forward paddle in working condition

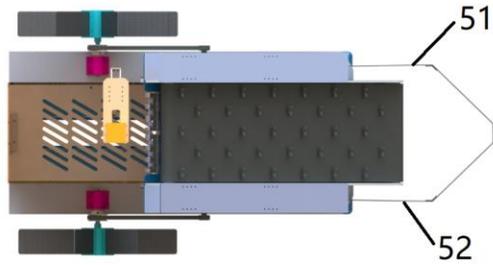


Fig. 3 Forward paddle in a non-working state

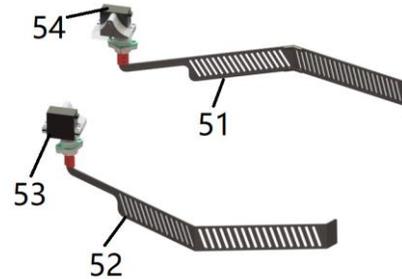


Fig. 4 Forward blade structure

3.2. Garbage Conveying Unit

The garbage conveying unit mainly comprises a toothed conveyor belt 61, baffle 62 and conveyor belt driving motor 63, as shown in Figure 5 below. The toothed conveyor belt is arranged on the main deck at an inclined angle, and the driving motor drives the conveyor belt to transport floating garbage on the water surface upward to the garbage storage box. The teeth of the toothed conveyor belt can play a certain anti-skid role, which is conducive to transporting common garbage such as plastic bags and mineral water bottles.

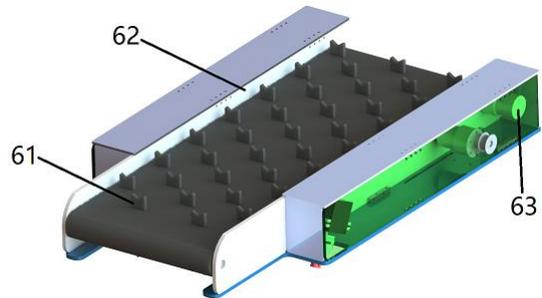


Fig. 5 Garbage transfer unit

3.3. Conveyor Belt Bonded Garbage Cleaning Unit

In the process of garbage transportation by toothed conveyor belt, some wet garbage with large water content is easy to bond on the toothed conveyor belt, which is not conducive to the continuous work of the conveyor belt. In order to remove the garbage bonded on the conveyor belt, a conveyor belt bonded garbage cleaning unit is designed, which mainly includes baffle teeth 71, rake teeth 72 and steering engine 73.

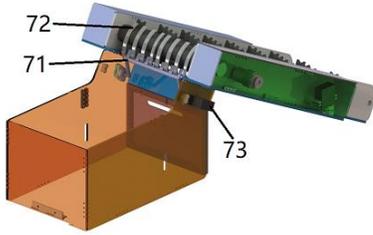


Fig. 6 Conveyor belt bonded garbage cleaning unit -- cleaning the garbage of the conveyor belt

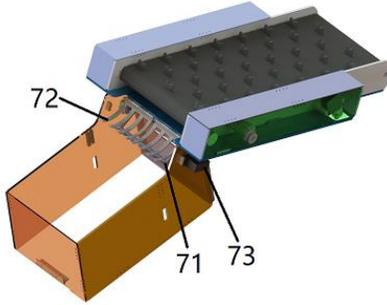


Fig. 7 Conveyor belt bonded garbage cleaning unit-- cleaning the garbage of rake teeth

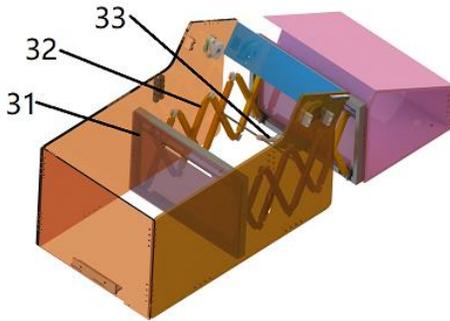


Fig. 8 Structure diagram of garbage dumping unit

When the bonded garbage on the conveyor belt needs to be cleaned, the state of baffle teeth and rake teeth is shown in Figure 6. At this time, the rake teeth contact the conveyor belt and separate the bonded garbage on the conveyor belt. When the cleaning of the bonded garbage on the conveyor belt is completed, the steering engine drives the baffle teeth to rotate, and the rake teeth turn down under the action of gravity and leave the conveyor belt. During the rotation of the baffle teeth, the teeth on the baffle teeth will scrape the garbage bonded on the rake teeth to the garbage storage box at the same time. The garbage bonded on the rake teeth will be removed automatically.

3.4. Garbage Dumping Unit

Considering the time and effort of manual garbage dumping, an automatic garbage dumping unit is designed, which mainly includes a pushing plate 31, shearing fork mechanism 32 and electric push rod 33, as shown in Figure 8 below.

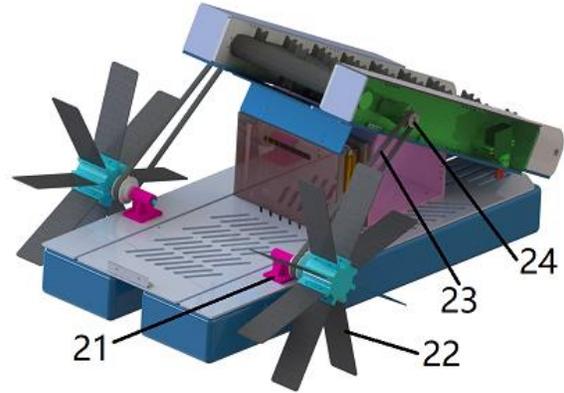


Fig. 9 Structure diagram of the walking unit

When it is necessary to dump garbage, it can push back the garbage in the garbage storage box through the electric push rod drive shearing fork mechanism and push the garbage out of the storage box. The garbage dumping can be completed at one time, effectively reducing the labor cost and improving the efficiency of garbage dumping.

3.5. Walking Unit

The walking unit mainly includes water impeller mounting seat 21, water impeller 22, synchronization belt 23 and driving motor 24. The motor drives the water impeller to rotate through the synchronous belt to realize the forward and backward movement of the hull. The turning action of the hull can be realized by controlling the rotation direction or speed of the two driving motors.

3.6. Garbage Identification and Positioning Unit

The garbage identification and positioning unit has a built-in camera and GPS positioning device, which is used to identify the surface garbage and locate the hull. The selected OpenMV4 intelligent camera, as shown in Figure 10, has a fast image processing algorithm, which can extract the outline of garbage and carry out image recognition of garbage to ensure the accurate completion of the task of garbage recognition [21-23].

The GPS positioning module is adopted, as shown in Figure 11. It can obtain longitude, latitude, altitude and other data through GPS data. Through data processing, coordinate transformation under the longitude and latitude coordinate system can be completed, and the data trajectory can be displayed on the computer for the convenience of observing the navigation process [26,27]. It can be connected to the single-chip microcomputer through the Type-C interface or the serial port interface to complete the data transceiver with the single-chip microcomputer. Real-time detection and positioning of the hull in the ocean or lake, easy to control the ship's whereabouts. When the ship deviates from its course or breaks down, the alarm sounds to remind the user of emergency treatment.



Fig. 10 OpenMV4 camera



Fig. 11 GPS positioning module

The control panel and battery module are installed in the control unit. The control unit mainly aims for the control water impeller drive motor, conveyor belt drive motor, forward propeller drive steering engine, baffle teeth drive steering engine, garbage dumping electric push rod, OpenMV4 camera, GPS positioning module and so on. The camera, GPS module and MCU send and receive data through the serial port. The single-chip microcomputer provides control signals to the motor and steering engine

through the output pin. It controls its speed by changing the signal to control the transmission speed of the conveyor belt and the speed of the water impeller. The later research and development process will also consider the connection between the single chip and the mobile network client to achieve a simpler and more efficient control effect.

4. Application and Prospect

Since the beginning of human activities, marine garbage has been increasing. In the 4.7 million square kilometres of the world's ocean, there are about 51 trillion microplastics, and every second, more than 200 kilograms of plastic waste into the ocean. Hence, we need to clean up a lot of waste, so we need garbage collection ships to make the ocean a cleaner and more beautiful environment, reflecting the absolute advantages of our products. In the later stage of continuous research, development, and improvement, we will focus on the capacity of the ship's storage and non-stop navigation problems.

5. Conclusion

A garbage collection ship for marine garbage collection is designed. Through a garbage collection unit, garbage conveying unit, conveyor belt bonding garbage cleaning unit and garbage identification and positioning unit, the efficient collection of surface garbage can be realized, and the labor intensity of manual garbage salvage can be reduced. The overall structure of the marine garbage collection ship is simple. The cost is relatively low and has a certain application value.

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