Integrated Intelligent Pollutant Cleaning System for Urban Lakes

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Abstract. Aiming at the problems of high manual labor intensity, low intelligence, and single cleaning types in urban lakes, from the perspective of practicability, an integrated intelligent pollutant cleaning system for urban lakes is designed and developed. The overall design plan is proposed, and the structure design and function development are completed. Through the integrated cleaning technology of solid and liquid pollutants, the simultaneous development of water body cleaning and water quality monitoring is realized. It also has the post-processing function of monitoring, cleaning and garbage cleaning of solid and liquid pollutants in urban lake water, realizing the integrity of the pollutant cleaning chain. Through the production and experiment of each part of the device, the control and function of the designed core pollutant cleaning ship are verified, which provides a basis for the application of the actual cleaning system.

1. Introduction

In recent years, China's investment in water pollution control has increased significantly. Under the guidance of government finances, the investment in environmental protection undertakings in various regions and cities has shown a rapid growing trend. In 2016, the State Council issued the "Thirteenth Five-Year Plan for Ecological Environmental Protection", which demonstrated the overall layout of ecological environmental protection, and clearly proposed the treatment requirements of black and smelly water bodies and floating garbage on the water surface, further defining the direction of water pollution prevention and control.

The existing pollution cleaning methods have obvious defects in the pollution of urban inland rivers, scenic lakes, reservoirs and other water areas. Intelligent cleaning ships have the advantages of low cost and low requirements for objective factors, and they are bound to become the mainstream of the future cleaning ships market. For example, in the current water area cleaning methods, the solid and liquid pollutant cleaning processes are independent of each other. This consumes manpower and material resources on the one hand, and on the other hand, it is difficult to achieve timely, effective and comprehensive cleaning of water pollution.

In response to the above problems, an integrated intelligent pollutant cleaning system for urban lakes was designed and developed, and the feasibility and practical application of the device were
experimentally verified to solve the overall treatment problem of urban lake pollution in detailed design.

2. Materials and methods
In this paper, considering the stability of the cleaning ship, the storage volume of pollutants, and the timeliness of the cleaning and transportation of pollutants, the design of the cleaning ship adopts a catamaran structure. In the process of the overall system design and the implementation of the modular design concept, the cleaning system is divided into three core parts: an integrated solid-liquid pollutant cleaning ship, an intelligent control platform, and hardware supporting equipment, including an integrated solid-liquid pollutant cleaning device, cameras and garbage transportation devices on ships and vehicles. The designed integrated intelligent pollutant cleaning system for urban lakes can realize autonomous cleaning of pollutants, upload water quality data, and intelligently transport pollutants.

It is introduced that the integrated system is divided into three parts: integrated solid-liquid pollutant cleaning ship, intelligent control platform and supporting equipment. Each part needs to be designed in detail in order to achieve the overall cleaning function of urban lakes.

2.1. Integrated solid-liquid pollutant cleaning ship
The designed solid-liquid pollutant cleaning ship is the cleaning module of the cleaning system, which can effectively deal with multiple combinations of solid and liquid pollutants.

2.1.1. Introduction to ship structure
At present, the cleaning process of solid and liquid pollutants on urban lakes is independent, and it is difficult to achieve timely, effective and comprehensive cleaning of the whole pollutants. Therefore, according to the characteristics of the ship structure, the combined function modules are designed. The designed integrated solid-liquid pollutant cleaning ship consists of five parts: pollutant information acquisition module, pollutant cleaning module, data transmission module, power supply module and controller module. Pollutant information is acquired by camera and transmitted to control system by data transmission module. The entire hardware system then receives the instructions from the controller and is powered by the power supply module to maintain normal operation and clean up the pollutants.

According to the pollution reports of many cities and lakes in China, we focus on the pollutant problems of floating garbage, metal pollution, black and odorous water body, and carry out research to develop cleaning ship, as shown in Figure 1. (1) A solid interception device is included, collecting floating garbage and other solid garbage, and flowing some small garbage and liquid pollutants to the next level for cleaning, as shown in Figure 2. (2) The impurity filter box adopts multiple filter grilles. There are 7 filters in the box, and filters with different holes are set to filter pollutants in different stages. (3) The oil pollutant cleaning tank adopts the inclined plate oil separation method. The device includes corrugated plate, grille, oil collection pipe and baffle plate. The tank body is connected with a negative pressure suction device and uses the density difference between oil and water to clean up the oil contamination in the liquid. (4) The multi-media filter box passes through triple filtration. The first filtration device is anthracite, quartz sand filter and gravel layer; the second one is activated carbon filter and gravel layer; and the third is microfiltration membrane. (5) Water quality testing device, electronic control valve and drainage pipe are installed in the water quality testing box. If the water body fails to meet the water quality discharge standard through the water quality testing device, the sewage will be stored in the sewage collection tank.
2.1.2. Design of cleaning ship volume parameters
The main task of this design is to integrate the cleaning of solid and liquid pollutants in urban waters. Considering that the task area is offshore waters, there may be many obstacles such as floating and moving ships, so it is necessary to clean the ship with good flexibility and obstacle avoidance performance. Therefore, referring to the work of Yunzhou Intelligent Technology Co., Ltd., the overall design dimension is shown in Table 1 under the condition of meeting the requirements of pollutant cleaning.

| Cleaning vessel parameters | Parameter values |
|---------------------------|------------------|
| Design chief (L)          | 1.1m             |
| Molded breadth (B)        | 0.7m             |
| Strip width (b)           | 0.15m            |
| Strip spacing (K)         | 0.38m            |
| Moulded depth (H)         | 0.3m             |

2.1.3. Analysis of resistance performance of offshore cleaning ship during navigation

2.1.3.1. Calculation of hull resistance
At present, there is no precise formula for calculating resistance in the design, most of which are estimated based on test or empirical formulas. Because the accuracy of this estimation method is difficult to guarantee, in order to obtain more accurate navigation resistance, this paper calculates and analyses the hull resistance at different speeds by ANSYSCFX software. As shown in Fig. 3(a) and Fig. 3(b), the velocity streamline diagram and the force analysis diagram of the hull can be visually seen.
The designed cleaning vessel is a small low-speed catamaran. Due to the low design speed, the calculation of the resistance of the offshore cleaning ship basically fits the expected design results.

2.2. Intelligent control platform
For the integrated solid-liquid pollutant cleaning ship, the Windows version (PC terminal) and Android version (pad terminal) control platform of this work effectively improve the application range and control accuracy. The designed intelligent control terminal of cleaning ship integrates water quality data monitoring, environmental information display of the ship’s position and manual remote control of the ship’s navigation. The hardware control system of the ship mainly includes: autonomous cruise system, on-board control system with terminal, water pump, camera, radar, GPS, GPRS communication module, ultrasonic sensor, STM controller and others. As shown in Figure 1(b), the designed terminal control system is controlled by a manager. With the environmental information perceived by the camera, the terminal control function mainly works by controlling the direction and speed of the offshore cleaning ship through the interface of the terminal. The on-board control system consists of industrial computer, universal bottom control system and GPRS communication system. Through the main interface of the control system, data such as GPS coordinates, speed, direction, energy consumption and internal information of the ship can be displayed to monitor the speed, direction and working time of the ship.

![Intelligent terminal](image)

Figure 4. Ground control terminal

2.3. Supporting equipment
In order to effectively solve the problems of the traditional water surface cleaning ship, such as the difficulty of cleaning and transporting and many dead corners, a ship-to-vehicle transportation device is designed as the supporting equipment. The operation process of the whole system does not need direct manual labor participation, only requires the operator to remotely operate the control platform, control the cleaning ship to sail directly to the position of floating garbage in the water area, collect the garbage, and monitor the water quality of the area where the cleaning boat is located. After the cleaning ship has effectively cleaned up the garbage in the water area, it will return to the transportation device. The garbage collection box of the cleaning ship is fixed with the transportation device through the mechanical structure. The operator controls the motor operation of the transportation device by using the control platform, and drives the garbage collection box to be transported to the vehicle, and finally controls the vehicle to transport the garbage to the garbage collection place. It efficiently solves the inconvenience of garbage cleaning in green plants and landscape lakes and the problems of water quality monitoring. The whole process is intelligent, which greatly reduces the number of personnel required for cleaning and saves the labor cost of users.
3. Results
In this paper, an intelligent cleaning scheme for urban lakes is proposed. The integrated solid-liquid pollutant cleaning ship is designed in detail, and the dynamic performance and energy consumption of the ship are analyzed. Through the prototype test, the feasibility of the control and function of the designed cleaning ship is verified, which provides a reference for the development of the new efficient intelligent cleaning scheme for urban lakes. The design of the integrated intelligent pollutant cleaning system for urban lakes improves the efficiency and accuracy of cleaning, greatly reduces the labor intensity, and provides a good working environment for employees, with the characteristics of simple operation, low power consumption and wide operation adaptability. It has high practical value for the cleaning and transportation of solid-liquid pollutants in urban lakes. Not only meeting the requirements of cleaning and transportation of urban lake garbage, it also reduces the dependence on human resources in the process of operation. With advantages of low operation cost, small size, environment protective, it will not cause secondary damage to urban lakes while cleaning urban lakes.

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