Design based on portable amphibious track robot

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Abstract. A portable amphibious robot that can operate on and under the waterline is designed for the special curved environment such as the pile leg of the offshore platform and the outer wall of the ship. The mechanical structure of the robot and the permanent magnet adsorption scheme of the magnetic adsorption track are designed. The robot can effectively complete amphibious tasks, and provides an effective way for amphibious tasks such as pile legs of offshore platforms and exterior walls of ships.

Keywords: Amphibious robot; Portable; Mechanical structure; Permanent magnet adsorption.

1. Introduction

With the passage of time, the metal wall above and below the waterline will inevitably appear corrosion, cracks, surface peeling and other problems. For example, the outer walls of the hull of large ships and the outer walls of the pile legs of offshore platforms need to be cleaned and overhauled regularly [1]. The traditional manual cleaning and maintenance operation has low efficiency, high risk and high labor cost. In order to solve many problems of traditional manual operation, people turn their attention to the field of robots, but there is still a big gap in the robot compatible with water and underwater functions.

In order to meet the requirements of robot hull inspection, it is necessary to have a complete control system and a strong adsorption and walking mechanism. So develop an amphibious robot that can do both above and below the waterline. The designed robot can be moved underwater by thrusters, and can also be adsorbed on metal walls by tracks. At the same time, due to its small structure and volume, it is convenient for manual carrying and placing recovery. By installing a cleaning or detection device on the robot, it can replace the manual cleaning or detection task, improve the detection efficiency and safety of the metal wall surface on the water and underwater, and achieve the purpose of reducing cost and increasing efficiency.

2. Amphibious robot system structure design

2.1. Structural model building

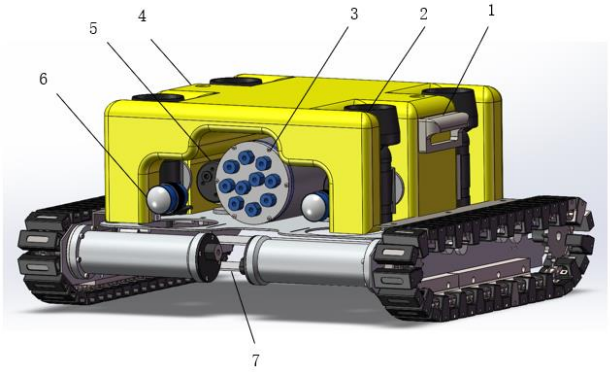
The robot uses the plastic buoyant material as the frame, which not only reduces the volume, but also makes the overall structure more compact. The technical parameters of the amphibious robot are shown in Table 1.

Table 1. Technical parameters of amphibious robot.

Index	Data
Size	390mm*450mm*250mm
Quality	20kg
Maximum operating water depth	100m
Nominal voltage	24V
Maximum wall climbing speed	5.40m/min

According to the idea of modular parameterization, the robot can be divided into buoyancy mechanism module, thruster power module, vision system module, magnetic adsorption track module and control module [2]. The buoyancy mechanism module is made of glass microbeads material,

which mainly provides buoyancy for the robot under water. The outer surface of the module is sprayed with polyurea to increase its strength. The embedded structure makes the buoyancy mechanism as the robot body structure and provides embedded installation environment for various instruments. As the power source of the robot's underwater movement, the propeller power module is used to control the robot's underwater movement [3]. The function of the vision system module is to observe and locate the target, and two lights are installed on both sides of the module, so that the camera can obtain higher clarity when working in a dark environment [4]. The adsorption unit of the magnetic adsorption track module selects a strong magnetic permanent magnet to ensure that the robot is stably adsorbed on the metal wall. The control module is the core module of the robot, and its main role is to provide control signals and power transmission for each component [5]. The robot system structure is shown in Figure 1.



1- Handle; 2 Vertical propeller; 3- Control module; 4- Buoyancy material;
5 Horizontal propeller; 6- Lights; 7- Magnetic adsorption track

Fig 1. Amphibious robot system structure.

2.2. How amphibious robots work

Propeller built-in DC motor, motor drive drive propeller rotation. The propeller adopts PWM control mode, and controls the motor speed by adjusting the duty cycle, so as to control the robot's moving speed and mode [6]. The robot body is equipped with a total of 6 thrusters, of which 4 are vertical thrusters and 2 are horizontal thrusters. The vertical propeller is installed at the four corners of the robot body, which can complete the movement in the three degrees of freedom of snorkeling, yawing and trim. Horizontal thrusters are installed on both sides of the robot body, which can complete the three degrees of freedom of movement on the horizontal plane: advance and retreat, rotation and roll [7]. The electronic governor of the propeller motor is installed inside the control compartment and is connected to the outside of the control compartment by watertight plugs and watertight cables.

As shown in Figure 2, there are four vertical thrusters distributed with symmetrical origin, They are respectively represented by T_1、T_2、T_3、T_4, and the two horizontal thrusters that are symmetrical about each other are respectively represented by T_5、T_6 .

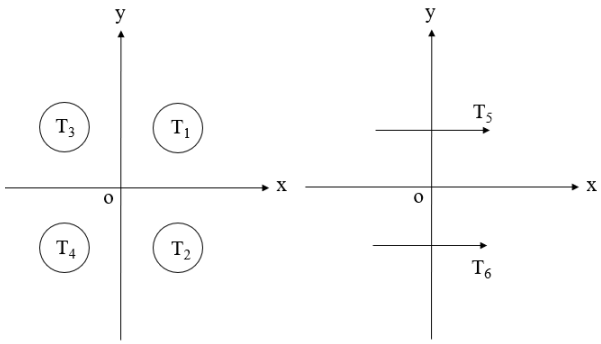


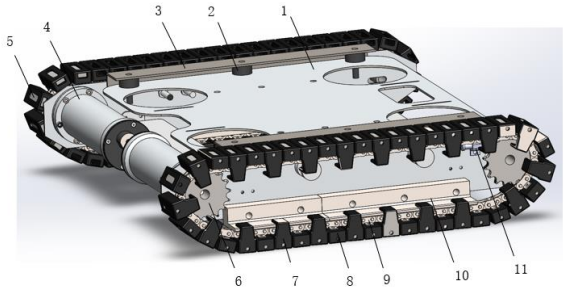
Fig 2. Layout of push machine.

The magnetic adsorption track can work on land or while adsorbing to metal walls, turning by differential motion of the underwater motor in the right and left directions.

3. Structure design of magnetic adsorption track system

3.1. Track system structure design

The structure of magnetic adsorption track system can be divided into track frame, drive module, walking module, adsorption module and other parts[8]. As the main structure of the magnetic adsorption track system, the track frame is not only the main structure of connecting the robot body, but also the main installation body of the track system components. The drive module is mainly composed of two 24V DC motors with aluminum alloy waterproof protective shell. Two motors are installed inside the walking modules on both sides. The walking module is mainly composed of two chain tracks, respectively installed on both sides of the track frame, and the track on each side adopts 06B double-sided curved plate single-row chain, which is connected with the self-made magnet shell. The 3D model is shown in Figure 3.



1- Support base plate; 2- Rubber shock absorber; 3 Connecting plate; 4- underwater motor; 5- permanent magnet; 6-sprocket; 7 magnet shell with bent plate; 8- magnet housing; 9- curved plate chain; 10-L plate; 11- Tension bolt.

Fig 3. Magnetic adsorption track.

3.2. Track component structure design

The adsorption module is mainly composed of a plurality of permanent magnet adsorption units, and the permanent magnet adsorption unit is composed of a permanent magnet and a magnet shell, among which the magnet shell is designed with a bending plate with a force, which is matched with the L plate in the track frame to ensure the stable and smooth operation of the track. The profile of the magnet shell and the curved plate chain are shown in Figure 4. The permanent magnet is installed in the magnet housing by interference fit, and the magnet housing is fixed on the chain bend plate by screws. It is known that the adsorption force of a permanent magnet on the metal wall is closely related to its distance, and the greater the distance, the smaller the magnetic adsorption force. In order to prevent the robot from falling when crawling on the metal wall and ensure the strength of the magnet shell, the side of the magnet shell close to the metal wall where the permanent magnet is installed is set to 1.5mm.

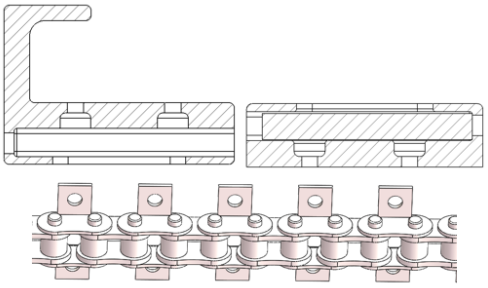


Fig 4. Profile of magnet shell with bent plate chain.

3.3. Selection of permanent magnets

After consulting the information, it was decided to use Ndfeb N52 as permanent magnet material. Ndfeb uses high-quality rare earth raw materials, hard and brittle, fragile, in order to avoid collision, designed with a magnet shell to protect the permanent magnet. Ndfeb, as a kind of permanent magnet material with strong magnetic adsorption properties, not only has high magnetic energy product and coercivity, but also has a low price [9-11]. The basic parameters are shown in Table 2.

Table 2. Performance parameters of Ndfeb N52

Remanent magnetic induction $\frac{Br}{mT}$	Coercivity $\frac{H_c}{KA \cdot m^{-1}}$	Maximum magnetic energy product $\frac{B_{k\max}}{KJ \cdot m^{-3}}$	Operating temperature $\frac{T_w}{^{\circ}C}$
1430-1480	828-907	398-422	<60

4. Summary

An amphibious robot is designed, which can be used not only underwater but also adsorbed on the metal wall above water. The robot model is established by three-dimensional software, and the structure of magnetic adsorption track is designed by permanent magnet adsorption scheme. It lays a foundation for the realization of the following functions of the robot on the water and underwater.

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