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A Mechanical Structure of a Frame Shaped Underwater Vehicle

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Abstract

The research and development of underwater robot is the inevitable result of scientific and technological progress. In this paper, a frame-shaped underwater vehicle is designed, which is suitable for multi-faceted work in shallow waters. The overall scheme highlights that the underwater vehicle has simple structure, convenient production, low production cost and high safety. The setting of relevant components is considered comprehensively to ensure its good performance in underwater work.

Keywords

Frame Shape; Underwater Vehicle; Shallow Water; Mechanical Structure Design.

1. Introduction

As one of the greatest inventions of mankind in the 20th century, robot technology has made great breakthroughs after decades of development. With the development of the world economy and the progress of science and technology, robot technology is gradually applied to every field of human life. In recent years, due to the urgent need of exploration and exploitation of Marine resources, underwater robot technology has been rapidly developed and widely applied. As an important branch of robotics technology, underwater robot technology integrates mechanical design, fluid dynamics, high-performance underwater power plant, intelligent control and modern underwater acoustic technology [1]. The research and application of underwater robot technology is of great significance in both military and civilian aspects. Militarily, it can be used to detect enemy military targets, carry out reconnaissance activities, and also be used to track enemy submarines, ships, aircraft carriers and other targets. In the civil aspect, it can be used in underwater imaging, offshore oil exploration, underwater operation[12], hydrology survey, bottom fishing, fish detection, fishing, ship navigation and seabed geological geomorphology survey [2], so the underwater robot technology is of great research value. There are three common mechanical structures of underwater robots [3].

Design requirements and common forms of body structure of underwater vehicle

As the working environment of the underwater vehicle is underwater, its mechanical structure design is more complex than that of the general mechanism design. It is necessary to consider various factors on the operational performance and working requirements of the autonomous underwater vehicle [4].

1.1 Related Principles and Requirements in Ontology Design

In general, when designing the body of an autonomous underwater vehicle Consider the following principles and requirements:

Low resistance, which is conducive to underwater navigation of underwater robot;

Sufficient strength to ensure that the underwater robot is in a certain water Under the depth of normal operation [5], without being damaged by water pressure;

Comprehensive consideration of the use of other relevant components on the robot form the requirements of structure;

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Reasonable space arrangement and mass distribution to ensure underwater machines The balance of man in water;
Under the premise of meeting the use requirements, reduce the weight of the underwater water as far as possible [6].
Good technology, convenient for the shape of the underwater robot hardware Make:
When autonomous underwater vehicles operate in water, they inevitably do Affected by the viscous resistance of water [7], it is not conducive to the operation of underwater robot Increased speed and flexible operation. So, reducing drag is part of the design A key point.

1.2 Type of Mechanical Structure

There are three common mechanical structures of underwater robots.
Open-frame underwater vehicle
This kind of underwater robot is supported by the frame as the main body, and each component is allocated and set within the frame [8]. It is convenient to design and manufacture the structure, but it will encounter slightly greater resistance during operation.Figure 1 shows the type of Frame-mounted underwater robot.

Figure 1. Frame-mounted underwater robot

Streamlined underwater vehicle
Structure design of this kind of underwater robot mimics the fish body, with low running resistance, but the setup of the main internal parts, the design of the external structure, and the manufacture are relatively complicated. Figure 2 shows the type of Streamlined underwater robot [9].

Figure 2. Streamlined underwater robot

Hybrid underwater vehicle
The hybrid type combines the frame shape structure with the streamline junction, so that it not only has good streamlined hydrodynamic characteristics, but also is conducive to the spatial configuration of related components [10].
In this paper, it is suitable for underwater observation, record, search, identification, collection of underwater samples and salvage of small objects in rivers, lakes, ponds, reservoirs, shallow seas and

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other waters. The structural design of the frame-shaped underwater vehicle in Figure 1 is designed and analyzed [11].

2. Design Software

Computer aided design software for constructing 3D models should be better Strong 3D modeling function and surface modeling function. In mechanica three-dimensional entity building Soliworks is the most widely used software.

Soliworks is a set of mechanical design automation software, used by users Widely used in machinery, automobile and aviation and other fields. Software in Soliworks There are three modules, namely parts, assembly and engineering drawing, among which "Parts" Modules include sketch design, parts design [12], surface design, sheet metal design and die With design, etc.

3. Frame and Shell

3.1 Frame

One of the characteristics of the frame type underwater vehicle is that it has an anti-collision frame. When the control signal is out of control, the water flow changes and other special circumstances, the anti-collision frame shows its importance to prevent the damage of the internal parts of the robot. In Figure 3, there is an underwater camera in front of the robot and a light beside it [12]. The left and right sides of the robot have a flotation aid, to help the robot maintain a certain strength in the water. The middle part is the control box, which is built with circuit board, control chip, battery and other components, and is the "brain" of the underwater vehicle. The main body is evenly distributed with four thrusters to maintain the robot's underwater balance as well as diving and floating. Behind the main body are two forward thrusters, which serve as units to control the operation of the robot. The front end and back end are circular arc design, which is convenient to reduce the resistance of the underwater robot moving forward and backward. Both the upper and lower parts are flat design, and the underwater resistance is relatively large when running in these four directions, so it is suitable for slow propulsion. Anti-collision frame is made of stainless steel hollow pipe welded, with convenient production, good anti-collision, low price, light weight and other advantages.Anti-collision frame is made of engineering plastic (HDPC) processing, has the advantages of convenient production, good anti-collision, low price, light weight and so on.Figure 3 shows the type of Structure diagram of a framed underwater vehicle.

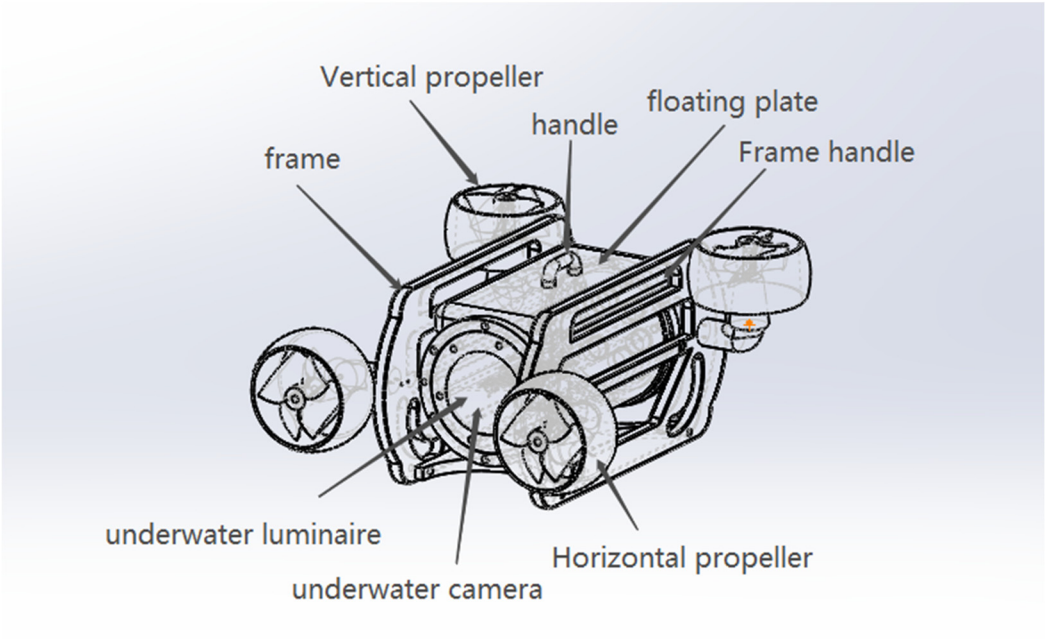

Figure 3. Structure diagram of a framed underwater vehicle

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3.2 Shell

In order to reduce the overall weight of the framed underwater vehicle, the choice of shell is very important. The material is manufactured to reduce the thickness of the shell as much as possible to reduce the overall weight under the conditions of underwater compression of the underwater robot. Due to the operation in shallow water, the shell thickness can be selected to be relatively thin, while considering the production cost, the use of engineering plastic acrylic plate. Good plasticity, good transparency, good transmittance, pure color, rich color, beautiful flat, long service life, does not affect the use of features, and especially convenient camera and lamp use [13].

4. Power Propeller

Thrusters give the underwater robot the power to navigate underwater. There are many types of thrusters, but propulsion The most efficient are propeller-type thrusters, most often electric thrusters, but sometimes hydraulic motors propeller [14].

As this underwater robot shoulders the task of underwater patrol cable, it is an observation underwater robot that needs to ascend, dive and dive forward The three translational movements of forward, backward and transverse movement and the three rotary movements of turning, roll and pitch require a total of 6 degrees of freedom.

4.1 Key Element of Propeller Layout

The movement of The layout of thrusters should follow the following points:

The axis of the propeller should be parallel to the axis of the moving coordinate system, so as to achieve maximum efficiency [15].

Maximize the intersection of the three axes of the propeller at the same point, and this point should coincide with the underwater robot's center of gravity, this This method can make underwater robot movement more stable and reduce the impact of unnecessary additional forces.

4.2 The Number and Placement of Underwater Robot Thrusters

Single propeller

The deployment of single propeller can only enable underwater robot to move in one axial direction. The propeller only generates thrust in one direction and cannot generate force and torque in other directions, so it has only one degree of freedom.

Parallel twin thrusters

Double thruster arrangement means that the axes of the two thrusters are arranged in parallel, and their axes are parallel to the moving coordinate system. The thruster still only generates thrust in one direction, that is, the forward force of the thruster axis, and the torque is obtained

In addition, when the movement of propellers running only one or two propellers is in the opposite direction, a torque is generated to drive the underwater robot to turn. The underwater robot has two degrees of freedom.

Cross twin thrusters

Crossed twin thrusters mean that both thrusters are at an Angle to the axis. Considering the limited space inside the underwater robot, the placement of the equipment sometimes affects the inflow of the propeller, reducing the propulsion efficiency. The cross arrangement of the thruster makes the axis of the thruster and the axis of the moving coordinate system produce an Angle, which improves the situation. The component forces on both sides of the thruster cancel each other and still keep the thruster moving forward. The axial component force is changed by adjusting the included Angle. When the included Angle between the two thrusters is 90°, no axial component force is generated in this case, so there is no force loss, but there is no torque to drive the underwater robot to rotate.

Four thruster vector arrangement

The mode of placing four thrusters in vector form in the same plane is called four-thruster vector layout, which enhances the maneuverability of the underwater robot. Since the underwater robot is responsible for the task of underwater patrol cable, strong maneuverability is required, and the first

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three layout modes are difficult to meet the task requirements, so the underwater robot adopts the fourth four-thruster vector layout scheme.

Power thrusters are the direct driving parts of the underwater vehicle operation. Two forward thrusters are designed at the rear end of the main body. When the propeller is turned forward, it pushes the underwater vehicle forward. The reverse rotation during propulsion will push the underwater vehicle backward; In a turn, only one of the thrusters needs to be driven, while the other is inactive. Balanced fuselage thrusters have four thrusters evenly distributed inside the main body, and the fuselage balance is maintained by turning the four thrusters individually or in tandem.

After all aspects of the design, Figure 4 is the frame type underwater vehicle

The mechanical structure of the 3D diagram.

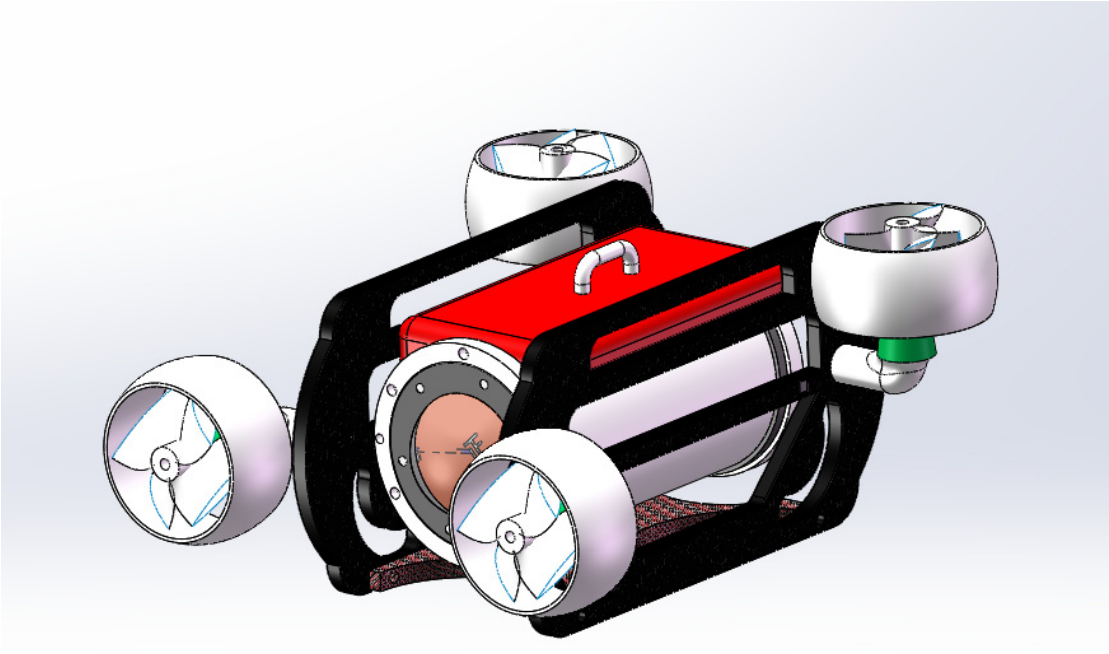

Figure 4. Mechanical structure of a framed underwater vehicle in three dimensions

5. Anti-corrosion Measures of Underwater Robot

Underwater robot only works under water, so it is necessary to consider the problem of anti-corrosion in the underwater environment. For the corrosion of underwater robots, there are mainly the following methods:

Metal parts, the metal surface oxidation treatment; Apply anti-corrosion paint to the surface of the oxidized shell; After launching work, fresh water should be washed in time to reduce seawater corrosion; Processing corrosion-prone parts and spare parts, regular replacement [16].

After all aspects of the design, Figure 4 shows three-dimensional mechanical structure of the frame type underwater vehicle.

5.1 Metal Preservative

1 Electrophoresis

Electrophoresis, also known as electrocoating, was first used in automotive primers by Ford Motor Company in the 1960s. Because of its excellent anticorrosion and antirust function, it is widely used in the military industry soon. In recent years, it has been applied to the surface treatment of daily hardware [17].

2 Anodic oxidation

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It is mainly the anodizing of aluminum, which uses the electrochemical principle to generate a layer of alumina film on the surface of aluminum and aluminum alloys. This layer of oxide film has protective, decorative, insulating, wear resistance and other special characteristics.

3 Micro arc oxidation

By applying voltage on the workpiece with a special micro arc oxidation power supply, the metal on the workpiece surface interacts with the electrolyte solution, forming a micro arc discharge on the workpiece surface. Under the action of high temperature, electric field and other factors, the metal surface forms a ceramic film, so as to achieve the purpose of strengthening the workpiece surface. Micro arc oxidation is mainly applied to aluminum, magnesium, titanium, zirconium, niobium, thallium and other valve metals.

4 Powder spraying

Powder spraying equipment (electrostatic spraying machine) powder coating sprayed to the surface of the workpiece, under the action of electrostatic, powder will be uniformly adsorbed on the surface of the workpiece, forming a powdery coating; Powdery coatings are cured by high temperature baking and leveling to produce final coatings with different effects (different kinds of effects of powder coatings).

5 Electroplating

Electroplating is the use of electrolytic effect of metal surface attached a layer of metal film process so as to prevent corrosion, improve wear resistance, electrical conductivity, reflective and improve the appearance of a technology.

5.2 Apply Anti-corrosion Paint

Antiseptic paint is a type of paint used on the surface of an object to protect the interior of the object from corrosion. It is a kind of paint commonly used in industrial construction, widely used in aviation, shipbuilding, chemical industry, oil pipeline, steel structure, bridge, oil drilling platform and other fields, favored by the majority of construction manufacturers [18].

There are many kinds of anticorrosive paint, according to the composition can be generally divided into: epoxy anticorrosive paint, polyurethane anticorrosive paint, acrylic anticorrosive paint, inorganic anticorrosive paint, vinyl perchloride anticorrosive paint, chlorinated rubber anticorrosive paint, high chlorinated polyethylene anticorrosive paint; According to the use can be divided into: pipeline anticorrosive paint, ship anticorrosive paint, metal anticorrosive paint, furniture anticorrosive paint, automobile anticorrosive paint, rubber anticorrosive paint; According to the solvent can be divided into: water-based anticorrosive paint, oil anticorrosive paint;

Anti-corrosion paint is a mixture of a variety of water-bearing silicate minerals, the main chemical group is Al_2O_3 and SiO_2 two oxides. Al_2O_3 mainly comes from clay minerals, and SiO_2 comes from particulate quartz in addition to clay minerals. The closer the Al_2O_3 content and Al_2O_3/SiO_2 ratio are to the theoretical values of kaolinite minerals, the higher the purity of such clays [19].

It can be used under harsh conditions, and has good durability, weather resistance, can be used in the ocean, underground and other harsh conditions for more than 10 or 15 years, even in acid, alkali, salt and solvent medium, and under certain temperature conditions, can also be used for more than 5 years.

6. Conclusion

In this paper, the mechanical structure of a frame type underwater robot is designed, which has the following characteristics: (1) light weight, good production process. (2) Frame shape design, low production cost, short production cycle. (3) Good dynamic stability. Reasonable configuration of four vector thrusters ensures that the robot can dive/float flexibly, and two forward thrusters can control left/right steering and other maneuvering capabilities, which is easy to operate and flexible. Combined with the research and design analysis of this paper, grasp the main aspects of the mechanical structure design of underwater robot, the shape, structure, size, material and layout of scientific and reasonable optimization design, at the same time pay attention to solve the practical work process may face

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various problems, to ensure the realization of the application function of underwater robot and improve the performance.

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