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A design of a bionic dolphin mechanical fish that can capture water energy

Yifan Yuan[1], Haoshen Ou[2], Wenjun Hou[3], Wei Zhang[4,*]

[1]*College of Machinery and Transportation, Southwest Forestry University, Kunming, 650224, China*
[2]*College of Engineering, Shantou University, Shantou, 515000, China*
[3]*College of Machinery and Transportation, Southwest Forestry University, Kunming, 650224, China*
[4]*College of Machinery and Transportation, Southwest Forestry University, Kunming, 650224, China*
[*]*Corresponding author: cangying176@163.com*

Abstract: *In order to design a bionic fish underwater vehicle that can capture sea current energy, this paper designs a bionic mechanical fish with dolphin shape characteristics that can collect sea current energy by studying the movement characteristics and physiological features of dolphins. When the water flow is fast, it can collect water energy through the energy capturing device in its head, and finally convert the kinetic energy of water into chemical energy stored in the battery; when the water flow is slow, the battery discharge can supply other components for normal operation. The underwater navigator uses STM32 as the control core to control the servo and motor work by changing the PWM value, and finally the underwater navigator can operate normally.*

Keywords: *bionic; mechanical dolphin; form design; energy capture*

1. Introduction

The rapid development of science and technology in recent years has made human beings not only satisfied with galloping on the land, but also have a stronger interest in exploring the marine world. Marine resources are the treasure house of the earth's resources, containing rich natural gas, oil and other resources. Nowadays, due to the complex and unknown environment inside the deep sea, it is difficult to exploit the marine resources on a large scale through the existing mining technology, and the exploration of deep sea areas is a major problem for human beings. The design of reliable unmanned underwater vehicles to investigate and explore the deep-sea environment has become a hot spot for human research. Most of the existing underwater vehicles have low efficiency, slow speed and short endurance, etc. [1].

Fish, the oldest of the vertebrates and they almost have inhabited in all aquatic environments on Earth, from freshwater lakes and rivers to brackish seas and oceans, and have evolved over hundreds of millions of years. Thanks to such a long underwater life and evolutionary career, their physiological appearance and locomotor properties have approached the perfect form of aquatic organisms. The low consumption, low noise and high maneuverability of fish during their rapid underwater movement are of great guidance for the development of underwater vehicles. Therefore, people gradually turn their attention to the efficient and flexible movement of fish itself in nature, by imitating the shape characteristics and movement of fish in nature, and applying the results to the research of underwater vehicles [2].

Since the bionic fish has become a research hotspot in the field of bionics at home and abroad, research institutions in the United States, Japan, the United Kingdom and China have successfully developed bionic fish with characteristics of different fish species, and have been applied in many different application scenarios [3].In nature, dolphins have a flexible and simple movement pattern, and their unique biological shape makes them less resistant to swim in water, which is more suitable as a bionic object for underwater vehicles.

Current energy is the fastest growing renewable energy source, which is generated by the more stable seawater flow in submarine waterways and straits, as well as by the regular seawater flow due to tides [4]. At present, there are few design studies on bionic mechanical dolphins that are designed for current energy capture devices. Therefore, in this paper, a bionic dolphin mechanical fish is designed by using SOLIDWORKS software modeling, and an energy capturing device that can capture sea current energy is incorporated into it, aiming to provide some theoretical reference for bionic fish design and manufacturing.

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2. Basic structure of bionic dolphin mechanical fish

2.1 Analysis of the general structure of the bionic mechanical dolphin

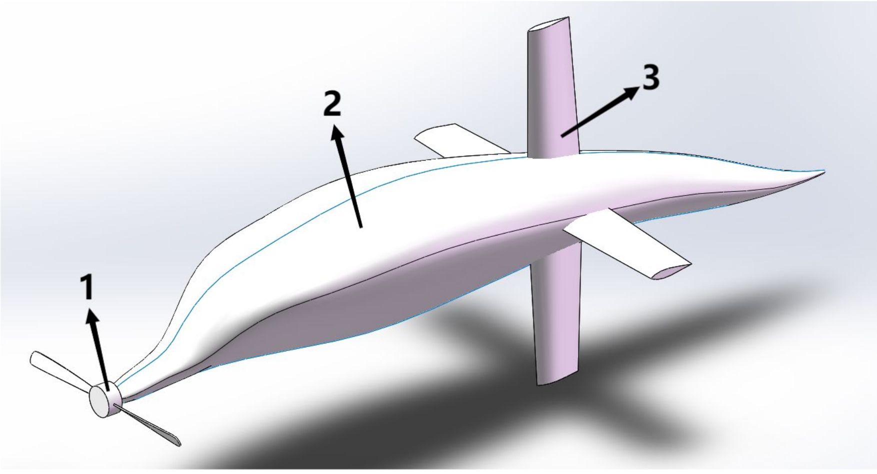

Figure 1: Overall structure of the model

Figure 1 above shows the energy capturing device, which is divided into two parts: internal and external. The external part is a two-page fan blade, and the internal part is a turbine, a speed booster, a generator and a battery installed inside the bionic dolphin fish body. The underwater fan consists of two single blades with a length of 65 mm. After the device enters the water, the impact of the water current will make the blades rotate, and the rotation of the blades will drive the generator to work, thus generating electricity.

In Figure 1 above, 2 is the shell of the main body of the bionic fish, with a total length of 540 mm and a width of 100 mm at the widest point. Using SOLIDWORKS software, the outline of the main body of the dolphin is drawn with a spline curve in the front view datum plane and the top view datum plane, a curve is established, and the surface placement function is used to make it take shape. At the same time, the interior of the fish body was hollowed out to facilitate the inclusion of various control elements.

In Figure 1 above, 3 is the tail steering mechanism, consisting of a pair of horizontal rudder surfaces and a pair of vertical rudder surfaces, with a maximum rudder diameter of 120 mm, embedded in the bionic fish body shell.

2.2 Introduction to the function of each part

2.2.1 Energy capturing devices

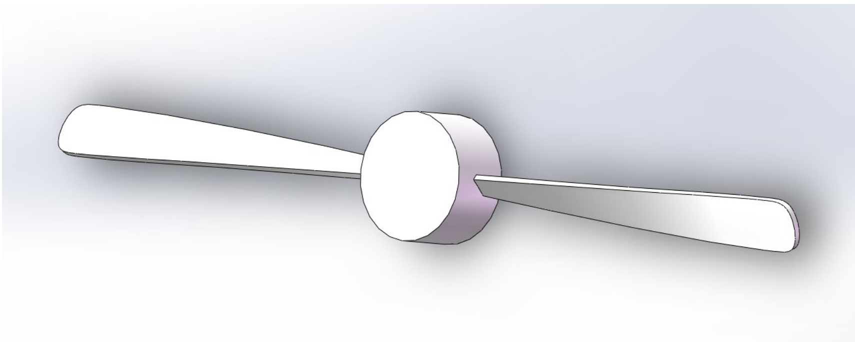

Figure 2: Energy capture device blade

Considering the relatively complex environment inside the ocean, the current impact is influenced by climate, geological activities and other factors, and also to reduce the weight of the mechanical dolphin, a two-page fan is selected, as shown in Figure 2 above.

The working principle of this part is mainly to drive the turbine rotation by water flow, and then use the speed increaser to increase the speed, so as to drive the generator to generate electricity, that is, the

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kinetic energy of water is converted into mechanical energy, and then the mechanical energy is converted into electricity. When there is water flow driving the blades, so that the turbine rotation, the generator power through the transformer rectifier, and then charge the battery to chemical energy saved in the battery; water flow force is weakened or disappeared, then use the battery discharge to drive low-voltage appliances.

2.2.2 Bionic fish body shell

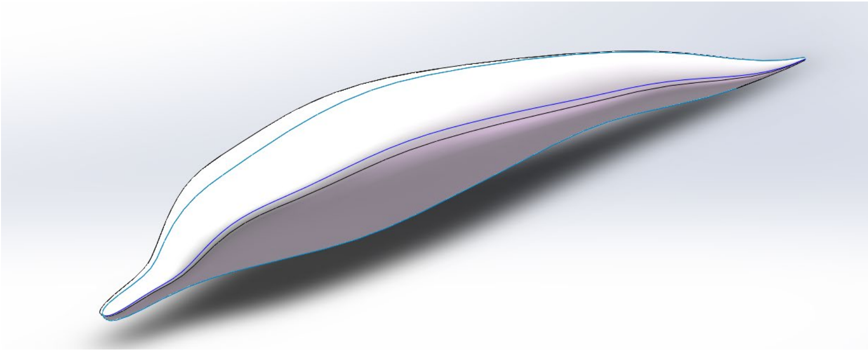

Figure 3: Bionic fish body shell

The main shell of the bionic fish is shown in Figure 3. above, with an overall streamlined design and a smoother transition with smoother curves to restore the main physiological characteristics of dolphins in nature as much as possible and reduce the resistance of the mechanical fish when traveling in water. At the same time, the design also simplifies the bionic shape as much as possible to reduce the production difficulty.

2.2.3 Tail regulating mechanism

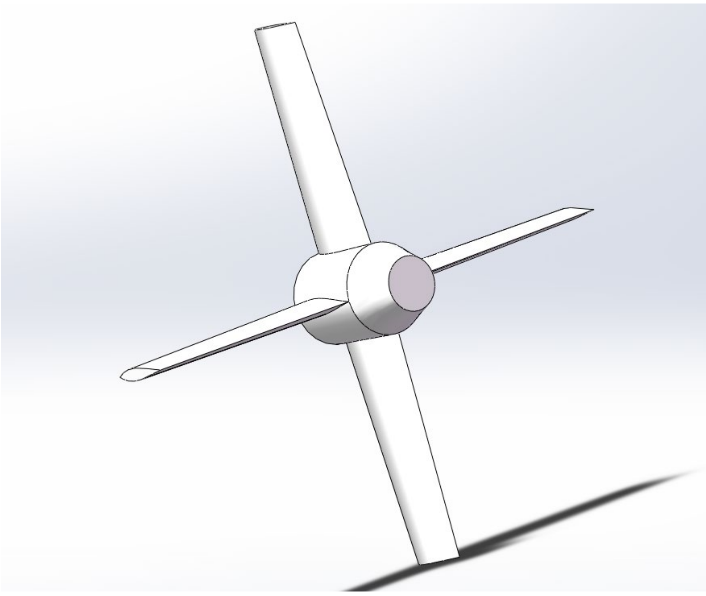

Figure 4: Tail-adjustment mechanism

The tail rudder, as shown in Figure 4 above, consists of two pairs of rudder blades. The upper and lower pair of rudder blades are responsible for controlling the horizontal heading of the mechanical dolphin, and the left and right pair of rudder blades are for controlling the vertical direction. Through the built-in electronic control system, the up and down, left and right heading control of the mechanical dolphin can be realized.

2.3 Control system integration

2.3.1 Overall program design

The mechanical dolphin is swum by changing three PWN values to control two servos and a DC motor. The overall scheme design is shown in Figure 5 below.

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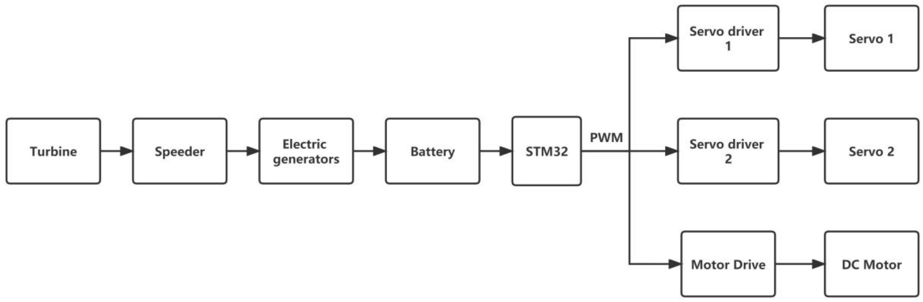

Figure 5: Hardware connection schematic

2.3.2 Selecting the master controller

This paper adopts the control core based on STM32, a 32-bit microcontroller developed by ST, which is a Cortex-M3 MCU. STM32's excellent performance has made it widely acclaimed and favored by engineers and the market, and no other chip can beat it. Compared with other controller chips in the market, STM32 has the advantages of lowprice, good real-time performance and rich peripheral expandability. The common STM32 can basically meet the requirements of the control chip for controlling mechanical dolphin in this design, so the STM32F103VFT6 model chip is chosen as the control chip for this design [5].

2.3.3 Selecting the drive

The rudder can control the direction of operation. Given that the mechanical fish in this design does not require high maneuverability and only needs to be able to complete simple steering actions, a high-torque servo is not required. Also to reduce the space inside the fish body occupied by the servo, the SG90 servo with smaller size and torque was chosen for this design.

As the power source of the whole mechanical dolphin, the motor should ensure the stability and reliability of the mechanical dolphin during operation, and also enable it to maximize its full performance. Combined with the movement requirements, the 365 DC motor was finally selected.

2.3.4 Selecting the motor driver board

From the operating voltage and power value of the 365 DC motor selected above, the domestic brand AQMH2407ND 12/24 V 7A 160 W DC motor driver board was selected for this design. The motor driver board allows DC voltage range of 6.5-27 V, under voltage protection, power transient interference suppression, rated current output of 7 A each way, enable signal can be connected externally to PWM, control signal using the current filling drive mode, support most of the microcontrollers direct drive.

2.3.5 Selecting the battery

The voltage required for each part is different, the working voltage of motor is 24 V, the working voltage of servo is 6 V, the maximum voltage in this control system is 24 V, so this paper chooses 24 V lithium battery to supply energy for the whole device. 18650 is the originator of lithium battery, the battery voltage is 3.7 V and 4.2 V, the capacity is 3100 mAh-3400 mAh, the range is strong. It has a strong battery life. Therefore, multiple 18650 batteries of different capacities are connected in series to form a 24 V power supply, with a capacity of 6800 mAh and a maximum discharge current of 10 A[5].

3. Conclusions

Through this design, a combination of a water energy capture device and a bionic dolphin mechanical fish body is realized to design a relatively rare bionic fish body underwater navigator. Its STM32 is used as the main control chip for motion control, and the energy capture device can collect the kinetic energy of the water flow and convert it into chemical energy for storage [6]. At the same time, the fish shell, which retains most of the physiological appearance characteristics of dolphins, can also reduce the resistance of underwater navigation to some extent, making its operation more efficient. In a way, the use of marine hydro energy is another sense of exploitation of marine resources. This approach has the advantage of being sustainable compared to traditional methods, and its impact on the marine environment itself is lower and more reliable for the protection of the marine ecosystem.

The tested water depth range for normal operation of this design is 1-2 m. In order to ensure its normal operation, the control elements inside the fish body must be treated with waterproof and

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anti-corrosion treatment. The housing material can be replaced by yourself according to different budgets and needs. This design is dedicated to provide some design ideas and theoretical reference for future bionic fish design combined with current force energy capture.

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