Selection and Study of Functional Modules for Amphibious Unmanned Search Vehicles

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Abstract. In recent years, since the 18th National Congress first proposed the strategy of a strong country of the sea, China has begun a series of measures to improve the ability to develop marine resources, develop the marine economy, protect the marine ecological environment, and build a strong country of the sea in all aspects. Although China's maritime search and rescue work at the policy level has made some progress, but the overall search and rescue system, the mechanical equipment process of propulsion is not yet mature, and the combination of existing search and rescue technology is not perfect, need more new thinking to. While the application of air search and rescue system has certain limitations, but the two search and rescue technology has gone through a long development, if it is applied to the marine level, it can better avoid terrain obstacles, so as to get better results.

Keywords: Marine power, propulsion, equipment process.

1. Research Background
As an important player in the world's economic activities, the role of the sea is becoming increasingly important. With the in-depth implementation of China's "ocean strategy", the maritime transportation environment has become more and more complex, highlighting many maritime transportation safety issues. Therefore, the search and rescue of maritime distress has become the focus of maritime research, to achieve "all-weather operation, all-round coverage, emergency rapid response" as the goal of maritime distress search and rescue.

At present, the maritime search and rescue is mainly done by manned search and rescue boats and search and rescue aircraft, search and rescue boats are slow, search and rescue aircraft are affected by the sea and weather conditions, resulting in a certain degree of search and rescue time urgency and spatial inaccessibility, bringing certain difficulties to the coordination, orderly and efficient development of search and rescue operations, increasing the wind of ships in distress or people in distress, and if we can better improve the navigator (Figure 1) itself mobility, improve its propulsion capacity, then the overall efficiency of the marine search and rescue system will be greatly improved.
2. Overall design

The navigator studied in this paper, its "trinity work system" is the most critical system innovation point, the choice of its new propulsion is the equipment innovation point, the combination of the two innovation points to achieve high efficiency, a wide range of work capabilities, is the greatest protection for people in distress.

First of all, we learned that the key to the success of a search and rescue operation lies in how to quickly search for people in distress and how to maximize the safety of people in distress before the arrival of rescuers. In response to this problem, the main body of the vehicle adopts the "multi-information feedback technology", so that it can simultaneously achieve synchronized information interaction with the main vehicle of the same fleet, the unmanned bionic boats of the secondary fleet, and the rescue personnel of the search and rescue center when sailing. On the one hand, the information collected by each fleet can be processed in real time to make judgments on the distribution of people and ocean currents in the area in danger, feed the information to the main control board processor in time to fine-tune the attitude of the navigator, and send the processed key information back to the rescue center to assist the rescuers to make new plans in time; on the other hand, the main navigator will act as a signal base station to ensure that the bionic unmanned boat fleet can use it as a basis for real-time positioning and coordinate feedback to achieve a carpet-type search without missing. The trinity linkage search and rescue system, in which the navigator sails, the unmanned boat fleet searches, gives first aid and feedback, and rescuers arrive and rescue according to the feedback coordinates, realizes the effective rescue of people in distress. On the basis of these two more advanced working modes, this paper further studies and researches the propellers used in the work of the vehicle, and studies the propellers of different working modes such as traditional propeller propellers and new shaftless propellers, in order to achieve low emissions and high efficiency, and expects to get the best working effect.
3. Comparison of functional modules

3.1. Water propulsion

(1) Dual rotor

At the beginning of the work design, for the consideration of flexibility and convenience, we first understood the current status of the dual-rotor flying machine. It is known that the existing dual-rotor aircraft are mainly divided into two kinds of co-axial dual-rotor and horizontal dual-rotor. Compared with the most popular quadrotor, the co-axial dual-rotor is more compact, easy to fold the rotor itself, but so far it is mostly used in military helicopters, and this helicopter in the rescue work, less load, slow movement, not suitable for emergency rescue.

The horizontal dual-rotor vehicle uses two sets of lift mechanisms (Figure 3), each of which can be independently deflected around the pitch axis. By controlling the lift provided by the two motors and the angle between the lift provided by the two lift mechanisms and the vertical plane, a total of four parameters are used to complete the control of three translational degrees of freedom and three rotational degrees of freedom of the vehicle to complete vertical takeoff and landing, translation and steering.

![Fig. 3. Transverse dual rotor structure.](image)

(2) Quadrotor

The quadrotor is one of the most commonly used rotors for UAVs and is also our primary consideration in selection. It uses direct torque to achieve six degrees of freedom (position and attitude) control with multivariable, nonlinear, strong coupling and interference-sensitive characteristics. Therefore, although the dual-rotor has the advantages of greater maneuverability and ease of transportation compared with the quad-rotor UAV, the rotors of the dual-rotor UAV are arranged forward and backward, which gives rise to a series of aerodynamic, flight dynamics and structural dynamics problems that are far more complex than those of the quad-rotor UAV, and accordingly its analysis and design technology are more difficult than those of the quad-rotor UAV. Therefore, this paper tends to choose the quadrotor with high carrying capacity, high transport efficiency and good stability to be equipped in the navigator.

3.2. Folding method selection

(1) "X" shaped fold

Since most of the vehicle factories are far away from the sea, in order to facilitate the transportation of the fleet of vehicles before they are put into work, the team set the vehicle quad-rotor as a folding type, and tried to study and design various folding methods. The common folding of the vehicle is "X" shaped folding and telescopic folding.

As the "X" shape folding is to make the navigator's own DC servo connected to the first stage crank shaft, the first stage crank and the first stage connecting rod through the pin mating connection, thus forming the first stage crank slider mechanism. The first-stage linkage is connected to the symmetrically arranged second-stage linkage and the second-stage slider by pin fit, the second-stage slider is connected to the guide rail, the guide rail is connected to the body by moving over the screw
fit, and the two quadrotor wing midpoints are connected to the body by pin fit, thus realizing the second-stage crank slider mechanism. This joint point, slider node and the first-level crank pivot are arranged in the same straight line.

When the navigator is in flight, the mechanism is shown as follows (Figure 4), and the second-stage crank slider mechanism is in the dead position, and thus, the quadrotor wing is locked by the second-stage crank slider mechanism. When the vehicle is in the navigation state, the first stage crank is driven by the servo to rotate 180 degrees, and the first stage linkage drives the second stage slider to move, thus completing the folding function of the two wings.

![Figure 4. Telescoping mechanism.](image1)

(2) Swastika fold

The team studied and improved the folding method of two common UAVs. While choosing a more stable "X" type quadrotor wing structure, we changed the way the wing folds, and designed an alloy joint in the middle of the wing to split the complete wing beam in two, finally forming a "swastika" shape fold (Figure 5). The weight of the four rotor blades can be distributed in the four directions of the hull when the vehicle is working, effectively avoiding rollover, and because of the customization of the flight control bracket with aluminum alloy, the weight can be reduced to be more conducive to navigation and stability, which is consistent with the rectangular hull design.

![Figure 5. Swastika fold.](image2)

3.3. Underwater propulsion device selection

(1) Conventional water jet propulsion

Propulsion water pump: The propulsion water pump is the core component of the differential water jet propulsion unit.
Piping system: mainly includes water inlet, water inlet grille, diffusion pipe, propulsion pump inlet bend and spout, etc.

Rudder and reverse rudder combination maneuvering equipment: Ships with differential water jet propulsion cannot rely on the reversal of the main engine and propulsion pumps to achieve reversal, but generally by trying to make the jet water flow reflexive to achieve.

![Figure 6. Water jet propulsion device structure diagram.](image)

The water jet propulsion device is the water flow through the inlet channel to the water jet propulsion pump energy conversion mechanism, after increasing the energy, and then through the guide vane body and nozzle, with a certain speed spray away from the stern, the reaction force generated by the water flow to push the ship forward. The reaction force generated by the water flow can realize the rapid turning of the ship and improve its maneuverability and rotation.

(2) Shaftless propeller

In this paper, we also study the common shaftless rim thruster (Figure 7), whose main components include: permanent magnet motor and controller, propeller, water-lubricated bearing and duct, and other components, and if equipped with a full rotation device, it can also realize 360° full rotation. The propeller has high power density, low vibration and noise; the bearing adopts water-lubricated bearing, no risk of slippery oil leakage; the control is flexible and suitable for intelligent ships. In practical applications, it has been successfully used in sightseeing boats and fishing boats, this type of shaftless thruster, can make up for the deficiencies of the traditional bearing in variable working conditions with insufficient bearing capacity to cope with more complex and variable working conditions, so this paper tends to apply the shaftless thruster to the existing search and rescue navigators to improve the search and rescue efficiency.

![Figure 7. Shaftless thruster.](image)
4. Application prospects
This paper takes the strategy of "accelerating the ocean power" proposed by the 19th National Congress as the source of inspiration, addresses the characteristics of marine work and the shortcomings of the original life-saving system, indulges in the selection and research of the working module of the amphibious unmanned aerial vehicle, especially the propulsion device, and proposes a relatively novel working mode to realize the trinity search and rescue system, which can play a greater role in the future. The research has proposed a relatively novel working model, which can play a greater role in the future development of marine economy.

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