Mechanical system design of water air amphibious variable wing UAV

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Abstract: With the rapid development of science and technology, the application of UAV is more and more extensive, but the application of UAV is only limited to a single space field. In addition, other space explorers such as vehicles, ships and submarines are also greatly limited and fail to break through the space restrictions. The market needs a UAV that can fly in a variety of environments to be applied in more realistic scenarios. In view of its limitations, the water air amphibious variable wing UAV combines the advantages of traditional UAV and submarine, and has great development prospects in the fields of marine rescue, environmental survey, biological tracking, entertainment experience and military development.

1. Introduction

In view of the UAV’s air flight, underwater navigation and water entry and exit functions, the frame structure with altitude difference and the main propeller and culvert auxiliary propeller with tilting function are designed innovatively. The frame is arranged like four axes, and there is a height difference between the main propeller and the auxiliary propeller of the culvert, so as to complete the water and water entry actions of the UAV. The main propeller and the culvert auxiliary propeller can tilt around the main axis and the secondary axis respectively to complete the switching of various operation modes of UAV, so as to realize the forward and backward, left and right yaw and left and right roll in the horizontal plane.

2. Mechanical structure design

2.1. Machine design

In order to make the UAV complete the flight tasks such as air and underwater operation and water air switching, three parts of main propeller, auxiliary propeller and airframe platform are designed. The height of the ducted auxiliary propeller is lower than that of the main propeller, so that the UAV can use different propellers to provide power when the water and air are switched. The ducted auxiliary propeller adopts six blade propeller to provide greater power under water, the main propeller adopts two blade propeller to provide greater lift in the air. The main propeller and the auxiliary propeller are controlled by the steering gear to make the UAV complete various actions. Figure 1 shows the model of a water air amphibious variable wing UAV.
2.2. Support of motion design principle
The water air amphibious variable wing UAV is a new type of composite UAV, which integrates the principles of two axis UAV, four axis UAV and tilt rotor aircraft. Air flight is divided into lifting and descending, forward and backward, turning, etc. The principle of four axis UAV is adopted for lifting and descending, and the auxiliary propeller of culvert is downward. Forward, backward and steering are based on the principle of two axis aircraft.

3. Body module

3.1. Main propeller
UAV adopts dual main rotor configuration to provide main power for lifting. The main propeller is a two blade propeller. When the propeller is driven by the motor, the inclined plane of the blade pushes back the air or water flow, so that the blade gets the reaction force, namely lift or propulsion. Figure 2 shows main propeller.

3.2. Ducted auxiliary propeller
The middle of the fuselage is connected with two ducted auxiliary propellers, which provide the propeller with beam action, and increase the lift or driving force by concentrating the airflow or water flow. It can provide lift force for UAV when it needs to rise rapidly; it can provide propulsion for UAV when it needs to move forward rapidly. When moving, air or water is inhaled from the suction surface of the blade and discharged from the discharge surface, and the UAV is pushed forward by the reaction force. The efficiency of propulsion can be greatly improved by using ducted propeller. Figure 3 shows ducted auxiliary propeller.
3.3. Body platform

The fuselage platform is composed of streamlined fuselage and various power devices, which connect all parts of the model into a whole, and the platform is equipped with necessary control elements. The smooth shape surface can effectively eliminate or delay the air boundary separation and vortex generation, which is conducive to improving the dynamic performance of the whole machine in the fluid. Therefore, after modeling the convective fuselage surface, we evaluate the smoothness of the surface. On this basis, we modify it to obtain the body shell with good curvature, reduce the resistance of the water air amphibious UAV and improve the operation efficiency. Figure 4 shows is inside the body platform, Figure 5 shows is streamline fuselage.

4. Propeller

4.1. Number of propeller blades

Considering that the water air amphibious UAV must be able to fly in the air and have a better operation in the water, two different blade types are selected to meet the operation requirements in the water and in the air at the same time. To sum up, double blade propeller and six blade propeller are selected.
4.2. Propeller size
When UAV is flying in the air and sailing underwater, it is affected by gravity and fluid resistance. In order to ensure the UAV to operate at a certain height and at a certain speed, it must provide the corresponding lift and thrust. The propeller should not only provide enough lift and thrust, but also adapt to the characteristics of water and air basins. Propeller and fuselage form a unified "linkage" in the air and water. The power device provides energy to make the propeller rotate to generate lift, overcome resistance, and enable UAV to run at a certain speed. When selecting the propeller, the linkage balance relationship between the propeller and the engine body must be satisfied, so that it can be well matched. Therefore, the propeller size must be compatible with the rated speed and rated power of the power system.

The speed of twin propeller is $12 \times 6$, so it is required to operate the UAV with small propeller size. Because in water, the thrust is mainly provided by two ducted auxiliary propellers, and the motor speed is limited, so it is necessary to increase the number of blades to increase the driving force. Therefore, the ducted auxiliary propeller is a six blade propeller with a size of $3 \times 5$.

5. Innovation and advantages

5.1. A new type UAV
It breaks through the space limitation of water and air. On the premise of ensuring normal flight, the water air amphibious UAV reduces the equipment volume and improves the comprehensive performance of the UAV.

5.2. Flexible and quick
In order to adapt to different operation modes, the propeller is used to change the flight attitude of UAV in the air, under water and at the critical point of water and air. At the same time, it can reduce the motion resistance and improve the flight efficiency.

5.3. Streamline fuselage
Because the body platform of the water air amphibious UAV is composed of streamlined fuselage and various power devices, the smooth curved surface can effectively eliminate or delay the air boundary separation and vortex generation, reduce the running resistance and improve the operation efficiency.

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