Design of Three-Rotor Vertical Takeoff and Landing Logistics UAV

Runsan Luo

Airport College, Binzhou University, Binzhou 256600, China

553455459@qq.com

Abstract

Taking future logistics UAV as the research object, around the aerodynamic layout, structure design, power energy and materials of logistics UAV, a new energy urban logistics vehicle with three rotors can take off and land vertically is designed. How to ensure the safety of UAV flying at low altitude, automatic control of logistics transportation, design aerodynamic layout, new energy technology, composite materials, and analyze transportation are discussed.The reliability and economy of UAV meet the requirements of logistics companies.

Keywords

Vertical takeoff and landing, UAV distribution, tilt Tri-Rotor.

1. Introduction

1.1 Aerodynamic Layout of Aircraft

1.1.1 Rotor layout

The overall la yout of Sky Wing Logistics UAV adopts unconventional Tri-Rotor configuration, that is, two main rotors and one auxiliary rotors.The left and right main rotors provide flight power, while the tail rotors ensure the stability of the UAV and provide the switching of thrust mode.Tilting rotor aircraft has unique performance advantages due to the integration of multi-rotor and fixed-wing modes, which largely meet the technical requirements of logistics UAV.

Fig. 1 XV-15 tilt-rotor aircraft

Tilting-rotor UAV is a new concept aircraft between fixed-wing aircraft and multi-rotor aircraft, which combines the advantages of helicopter and aircraft. The new configuration principle of the aircraft has not only the multi-rotor vertical takeoff and landing, hovering in the air, good low-altitude and low-speed flight ability, but also the fixed-wing aircraft altitude cruise flight ability.

Tilting rotor aircraft can take off and land vertically and hover in the air, which greatly reduces its take-off and landing space and ensures high flexibility in the air.Of the three rotors, the left and right rotors can tilt forward and backward, and the tail rotors can tilt forward and backward.When the left and right rotors are in the vertical position, the aircraft can hover. The three rotors provide lift together. The tail rotors can tilt left and right to control the yaw angle. When the three rotors are in the horizontal position, the left and right rotors provide pull force corresponding to the fixed-wing mode. The lift force is completely provided by the aerodynamic force.

Fig. 2 BA609 Tilting Rotor

For example, the vertical take-off and landing phase provides vertical lift and the stable cruise phase provides forward thrust. Compared with the current civil helicopter, the rotor aircraft has the characteristics of low noise, high efficiency, smooth flight and convenient flight, which is more in line with the requirements of future manned flight. The mission profile of an aircraft is shown in Figure 1.1.3.The flight profile covers the takeoff, climbing, cruise descent and landing of the aircraft. The fuselage structure of the whole "Tiancheng Wing" aircraft is made of composite materials. The energy system is composed of light solar panels, which is clean and environmentally friendly. The advantage is that it can well adapt to the special environment and needs of urban development, small size, energy saving and environmental protection.

1.1.2 Tailless Flying Wing Layout

Sky Wing Logistics UAV, 920 mm in length and 1782 mm in wingspan, uses front triangle landing gear. The landing gear is located below the rotor. The weight of the airplane is 6.2 kg, the maximum takeoff weight is about 30 kg, the maximum mission load is 33 kg, and the power supply is 50,000 mah. Fully meet the needs of daily logistics transportation. The tailless flying wing layout simplifies the structure of the aircraft, reduces the take-off weight and achieves good lift-drag characteristics. The aerodynamic load distribution is reasonable and the efficiency is high. Flying-wing UAV adopts wing-body fusion technology, the whole body is a wing, carrying all aerodynamic loads, and the whole body is a lift surface, which increases lift to a certain extent. Compared with the conventional tilt-rotor UAV, the downwash airflow generated by the wing will not affect the fuselage, and the airflow disturbance is smaller.

2. Dynamic System

The power system is simple and efficient. A single engine provides both flight and navigation power requirements, which simplifies power design.It meets the basic power requirements of navigation, flight and vertical takeoff and landing, has high structural stability, achieves stable operation during tilting, and can accurately control speed and angle.

In order to ensure that the UAV can operate normally in bad weather conditions, the "Wing of the Sky" UAV can be waterproof, use waterproof motor, arrange drainage holes under the motor, encounter rain and snow weather, to ensure the normal flight of the UAV, without increasing the load.

After comprehensive consideration, three-blade propeller is selected as the power device of UAV.The dynamic parameters can meet the design requirements. For example, at 30 m/s, the speed of motor is 1481 r/min, the transmission efficiency can reach 85%, and the maximum pull force of single engine with rotor length reaches 198N at 2200 r/min. In order to stabilize the lift demand, the blade length can be lengthened to meet the lift demand of single engine with maximum 250 N.At the connection

point between engine and engine, the overall power system structure is formed by connecting the high strength torsional connection device.

3. Energy Power System

The UAV uses solar power generation system, which makes full use of the surface area of the aircraft and attaches solar panels to the surface. Whether the UAV works or not, and weather conditions permit, the solar power generation system will always charge the solar cells by converting the energy contained in the sunlight into electricity through photoelectric conversion.More environmentally friendly and efficient.

The above energy can be used as the power design scheme of the "Wing of the Sky" logistics UAV: Considering the safety, we can use electric energy as the main energy and solar energy as the standby energy, which can be used to solve the problem of insufficient solar power and stability.

4. Application of Composite Materials for UAV

With the continuous development of UAV technology, the requirement of material performance and function diversification design for the airframe structure of small UAV is very high.As a new material, composite material has high specific strength, specific modulus, excellent fatigue resistance, corrosion resistance, plasticity and stealth, and is very suitable for UAV manufacturing materials.At present, the most widely used composites in UAV are tree carbon fiber composites and fiber composites.The structural design and strength analysis of composite UAV should make full use of the mechanical properties of composite materials, and combine the design characteristics of UAV overall structure layout, so that the excellent performance of composite materials can be better brought into play.

The use of composite materials can reduce the total weight of UAV by 15%-45%.Initially, composite materials were mainly used in secondary load-bearing components of UAV, such as elevator (20% of the weight of UAV).However, in order to continue to lose weight, composite materials must be used in the main load-bearing structures, such as tail wing, fuselage and other components.

Considering the slow flying speed, frequent use and noise reduction of the UAV, the UAV uses carbon fiber layers, and uses coagulants and epoxy resin as wing, fuselage and other structural materials.The die for the whole fuselage and wing of UAV was designed and processed. The horizontal tail was manufactured by manual wet paving and vacuum curing at room temperature.Aircraft aluminium alloy is used as the structural material of wing and fuselage joints to improve the overall strength of UAV.

5. UAV Intelligent Control System

At present, the control system of Four-rotor UAV can realize one-key return flight, fixed-point flight and intelligent tracking flight.With the continuous development of science and technology, the functions of self-diagnosis, self-repair and self-adaptation should be constantly reflected in the aircraft, and the control and structural intelligence should be realized.It is no longer a problem to realize unmanned aerial vehicles in the future.The improvement of the "Wing of the Sky" UAV on the basis of the current aircraft can achieve fixed-point return, automatic obstacle avoidance, and the use of GPS positioning can freely set the route for fixed-point launch.Automatic fault detection, when the UAV carries out damage (stealing goods, destroying the UAV, interfering with the normal operation of the UAV), the UAV can automatically alarm, in order to ensure the safety of goods and people's lives and property.

6. Tilting mechanism

The tilting mechanism steering gear drives the tilting mode of the motor base. The left and right rotors rotate coaxially. Through the rotation of the conveyor belt, the motor rotates around the lateral support rod.The rocker arm of the steering gear is connected with the connecting rod, and the connecting rod

is connected with the expenditure end of the motor base to realize the steering gear drive tilting.The advantage of this method is that it is easy to adjust, and the tail rotor can be adjusted by mechanical physics and remote control during tilt adjustment.Physical regulation is regulated by metal regulator and rocker hole selection. Remote control regulation is regulated by fine-tuning button and rudder quantity of remote control.

7. Warehouse design

The warehouse should be suitable for transportation to meet the requirements of GB/T 16606.1-16606.3-2018 Express Packaging Supplies. Flying wing logistics UAV adopts wing-body fusion technology, which is a wing as a whole and has large loading space.There is enough space inside the fuselage fuselage to load all kinds of logistics cargo.

In order to maximize the volume of UAV, the fuselage is divided into different areas. The fuselage is responsible for loading heavier and larger objects, while the other parts can load smaller and lighter items.According to the demand, the cargo hold can be divided into several layers according to the need, making full use of the unmanned aerial vehicle, which has good sealing ability and can be effectively dustproof and waterproof.To meet the needs of thermal insulation, fixed anti-collapse, cushioning anti-shattering and so on.At the same time, the cargo hold has realized automatic control, which can realize the fixed-point delivery of cargo.

Acknowledgements

Binzhou University "Young Talents Innovation Project" Research Fund Project (BZXYQ NLG2018011).

References

[1] Platform Design of Light and Large Load Fixed Wing Logistics UAV [J]. Computer Products and Circulation, 2019 (5).
[2] Anderson S B. History overview of VSTOL aircraft technology [R]. NASA-TM81280, 1981.
[3] Congressional Research Service Reports. Library of Congress. Congressional Research Service.2010.
[4] Wang Wei [1], Duan Zhuoyi [1], Zhou Lin [1]. Design features and difficulties of tilt-rotor aircraft [J]. Aeronautical Science and Technology, 2015 (3): 1-4.
[5] Huang Zihao. Conceptual design of Tri-Rotor vertical takeoff and landing new energy urban aircraft [J]. Equipment management and maintenance, 2017 (17): 25-26.
[6] Mialon B, Fol T, Bonnaud C. AERODYNAMIC OPTIMIZATION OF SUBSONIC FLYING WING CONFIGURATIONS [J]. 2013.
[7] Liebeck, R. H. Design of the Blended Wing Body Subsonic Transport [J]. Journal of Aircraft, 2004, 41 (1): 10-25.
[8] Sun Aviation, Guo Yuqin, Tang Pengpeng, etal. Study on Shear Fracture Behavior of Carbon Fiber Composites [J]. Material Report, 2015, 29 (4): 64-6881.
[9] Cheng Deng. Structure and Function of Composite Materials and Their Applications in the Field of UAV [J]. Contemporary Chemical Research, 2019, 37 (01): 130-132.