ISSN:2790-1688 DOI: 10.56028/aetr.2.1.9

Design of Self-floating Device For Spherical Aircraft Based on Miniature Electromagnetic Lock

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Abstract: Aiming at the phenomenon that the aircraft is easy to fall into the sea due to adverse environmental factors such as strong wind and collision, which makes it difficult to recycle, a self-floating device based on miniature electromagnetic lock is proposed in this paper. The core circuit of the device takes 51 Single-Chip Microcomputer as the control core and Bluetooth module as the auxiliary control unit. The electromagnetic lock control system is designed and developed, and through the control of the electromagnetic lock on and off to pop corrugated folding airbag and reflector. Finally, the airbag is inflated to float the aircraft on the sea surface, and the reflective effect of the reflector makes the aircraft easy to find and recycle. The device is safe and reliable, easy to implement and low cost.

Keywords: Miniature Electromagnetic Lock; Sing-Chip; Corrugated Folding Airbag; Reflector

1. Introduction

With the continuous development of aircraft intelligent technology, aircraft are widely used in public security, military, production and other fields, which plays an important role in enhancing a country's comprehensive strength. Spherical aircraft has a small volume structure, and has gradually become a research hot spot in various countries because of its simple structure, easy control and low cost.

However, when the aircraft is operating at sea, it is easy to fall into the sea due to adverse environmental factors such as strong winds and collisions. If it is not treated, the aircraft will sink into the sea due to its gravity, causing difficulties in recovery. This will not only cause economic losses to researchers, but also pollute the marine environment.

Therefore, in order to solve this problem, a self-floating device suitable for spherical aircraft is designed in this paper. The device can increase the buoyancy of the aircraft by inflating the corrugated folding airbag when the aircraft falls into the sea, and increase the probability of the aircraft being searched and found through the reflection of the reflector.

2. Research background

In recent years, unmanned intelligent devices have become a hot topic. The development history of aircraft can be traced back to the 1920s. Early aircraft were mostly used as target aircraft. It did not emerge until several local wars in recent 20 years, and gradually developed into one of the important components of weapons and equipment in all countries in the world, especially in

ISSN:2790-1688 DOI: 10.56028/aetr.2.1.9
developed countries. In 1991, a large number of aircraft participated in the Gulf War, and the development of aircraft entered a new situation[1]。

At present, the development of domestic aircraft is booming and the scope of application is expanding day by day. This is due to the advantage that aircraft can perform boring, dirty and dangerous tasks, which liberates people from such work. At present, it is reported that Chinese aircraft have entered the field of marine and maritime applications。

In terms of marine application, the aircraft marine monitoring application system has the characteristics of fast response speed, strong mobility, large coverage area, wide sight distance range, high spectral and spatial resolution and low cost. It can be used for reclamation law enforcement supervision, protected area supervision, marine environment monitoring and evaluation, typical sea area monitoring and evaluation, marine ecological disaster monitoring, marine oil spill monitoring, marine animal and plant protection, etc. For example, rainbow-4 UAV is equipped with automatic ship identification system, which can perform tasks such as long-distance and large-scale sea area patrol, emergency search, ship oil spill and sewage monitoring。

However, when operating at sea, aircraft need to face unpredictable sea winds and harsh weather conditions, as well as the risk of collision with creatures flying at sea[2]. Once the aircraft fails to deal with these dangerous situations, it is very likely to fail, unable to continue operation and fall into the sea. When the aircraft falls into the sea, if it is not treated, it will eventually sink into the sea due to its own gravity, resulting in difficult recycle, which will not only bring economic losses to people, but also pollute the marine environment. Therefore, when the aircraft falls into the sea, it is very necessary to study how to make it float successfully and be found by people when searching. To solve this problem, a self-floating device is designed in this paper.

3. Device design

3.1 External structure

The external overall structure of the self-floating device is shown in the Figure 1. The device has a simple structure and is composed of three parts, the outermost is the roof plate of the spherical aircraft, and the middle is a ventilated version, and an ejection device is sandwiched between them, which is installed in the storage slot. It can be seen that there are several connections on the edge of the device, so the device is suitable for the spherical aircraft whose shell is connected longitudinally by several arc frames with oval cross section, and the device is the connection point at the top of all the arc frames.

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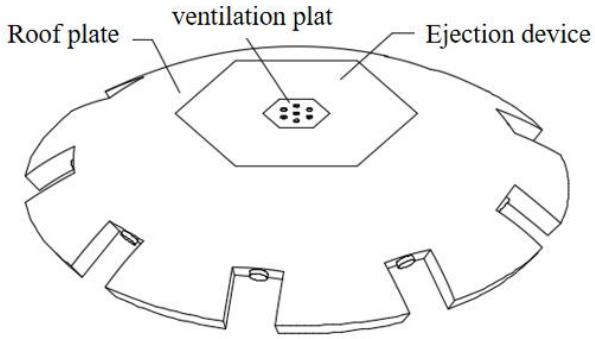

Figure 1 External integral structure of self-floating device

3.2 Internal structure

3.2.1 Integral structure

The main structure of the self-floating device is an ejection device, and its internal structure is as follows. Among them, Figure 2 shows the explosive structure of the ejection device, Figure 3 shows the structure at the position of the corrugated folding airbag, and Figure 4 shows the side section structure of the storage cylinder.

In the following figures，2 is the corrugated folding airbag, 4 is the mounting cylinder, 5 is the miniature electromagnetic lock, 6 is the bottom cylinder, 7 is the receiving cylinder, 8 is the connecting cylinder, 9 is the trigger spring, 10 is the one-way valve, 11 is the first support frame, 12 is the second support frame, 13 is the inflatable spring, 14 is the slide, 15 is the slider, 16 is the lock tongue, 17 is the lock, 18 is the cover plate, 19 is the ventilation plate, and 20 is the reflector.

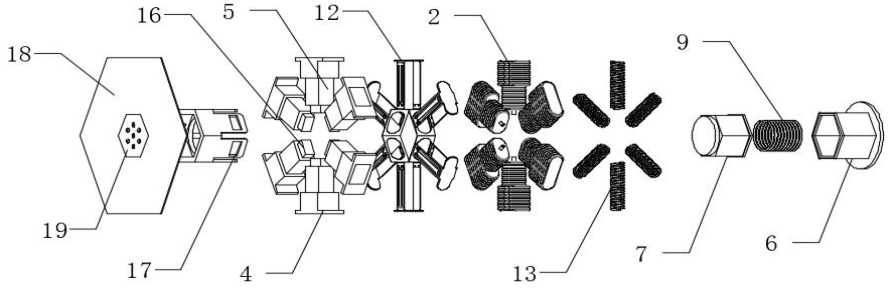

Figure 2 Explosive structure of ejection device

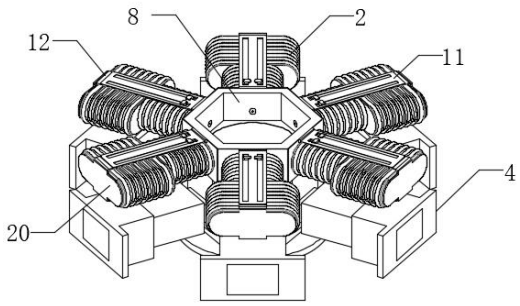

Figure 3 The structure at the position of the corrugated folding airbag

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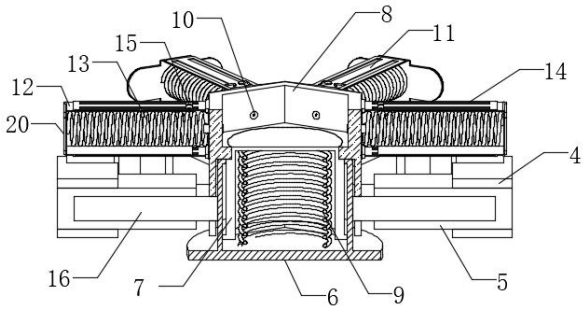

Figure 4 Side section structure of the storage cylinder

3.2.2 Connection mode

An one-way valve is installed on one side of the corrugated folding airbag, a storage slot is arranged at the top of the aircraft roof, the inner bottom wall of the storage slot is connected with a bottom cylinder, the inner wall of the storage slot is connected with a mounting cylinder, and the inner wall of the installation tube is equipped with a miniature electromagnetic lock. The inner wall of the bottom cylinder is slidably connected with the receiving tube, the outer wall of the receiving tube is fixedly connected with the connecting cylinder, and a trigger spring is arranged between the bottom tube and the receiving tube. Besides, one end of the one-way valve runs through the outer wall of the connecting cylinder and extends to the inner wall of the connecting cylinder, the outer wall of the connecting cylinder is fixedly connected with a first support frame, the inner wall of the first support frame is provided with a second support frame, and the inner wall of the corrugated folding airbag is connected with an inflatable spring.

3.2.3 Structural advantage

One end of the corrugated folding airbag is fixedly connected with the inner wall of the first support frame, and the other end of the corrugated folding airbag is fixedly connected with the inner wall of the second support frame, so that the first support frame and the second support frame are used to support the corrugated folding airbag.

A sliding port is arranged on both sides of the first support frame, one side of the second support frame is fixedly connected with a slider, and the first support frame is slidably connected with the second support frame through the slide port and the slider, so that the first support frame and the second support frame will not hinder the expansion and expansion of the corrugated folding airbag.

The output end of the miniature electromagnetic lock is equipped with a locking tongue, the outer wall of the connecting cylinder runs through and is provided with a locking port, and the outer wall of the locking tongue is sliding connected with the inner wall of the locking mouth, so as to limit the position of the device.

The top of the connecting cylinder is fixedly connected with a cover plate, and the inner wall of the cover plate is fixedly connected with a ventilation plate,

and the ventilation plate is located on the top of the cover plate to facilitate the protection of the interior of the device; the top of the ventilation plate is provided with a ventilation hole, and the ventilation plate is used to ensure the air circulation outside the one-way valve.

The outer wall of the second support frame is fixedly connected with a reflector, and the outer wall of the reflector is sliding connected with the inner wall of the storage slot, which is conducive to the ejection of the reflector[3].

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3.3 Core circuit

The core circuit structure of the device described in this paper is shown in Figure 5, which is composed of three parts: power supply module, core processor and miniature electromagnetic lock driving circuit.

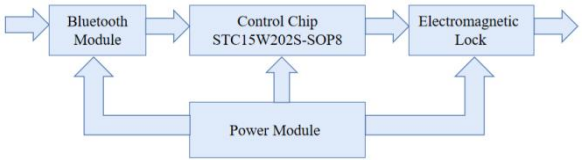

Figure 5 Core circuit structure

3.3.1 Power supply module

The power supply module can be divided into two parts, one is to adjust the output voltage of 5V to supply power directly to the core processor, and the other is the 5V to 12V module to supply power to the miniature electromagnetic lock.

The electric output voltage of 5V can not only be directly connected to the core processor, but also supply power to the steering gear of the spherical aircraft. The miniature electromagnetic lock is an electric lock designed by the principle of electromagnetism, which can be opened by electricity and locked when the power is lost. Its normal working voltage is 12V, so the MC34063 chip is selected to boost the voltage, and the voltage of 5V is converted into 12V, so that the miniature electromagnetic lock can be used normally[4]. The circuit diagram is shown in Figure 6.

3.3.2 Core processor

The core processor is composed of HC05 Bluetooth module and STC15W202S single chip microcomputer.

HC05 Bluetooth module is a very commonly used Bluetooth module. It not only realizes AT instruction to set and query relevant parameters through a serial port TTL interface, but also realizes serial port data transmission. It has six interfaces, one ground port, two voltage interfaces, one KET interface and two communication interfaces[5].

STC15W202S single-chip microcomputer belongs to STC15 series single-chip microcomputer, 15 series single-chip microcomputer is a major category of STC series single- chip microcomputer, belongs to the category of 51 single chip microcomputer. Compared with the traditional single-chip microcomputer, its speed is faster, and the speed of 1T mode is 8-12 times faster than that of the traditional 51 single-chip microcomputer. The internal (on-chip) RAM is relatively large, with EEPROM (served by FLASH) function, AD function, SPI interface, timer with PWM function, simple burning and writing. Built-in high-precision clock, reset circuit, anti-interference, encryption is stronger, and the price is cheaper[6].

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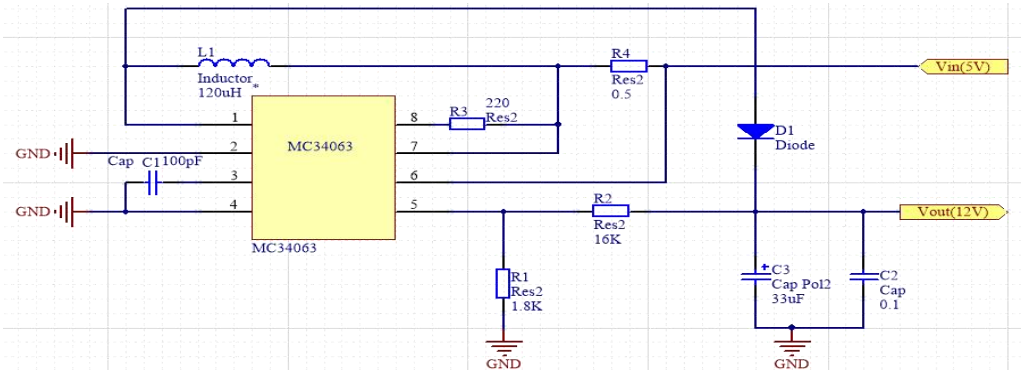

Figure 6 5V to 12V circuit diagram

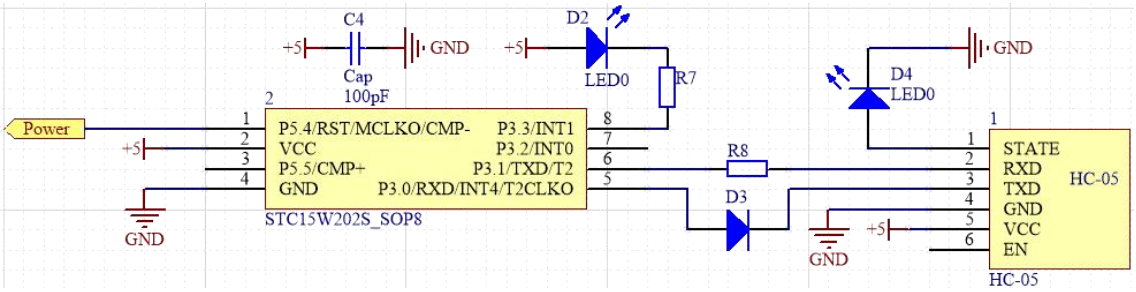

Figure 7 Working circuit diagram of core processor

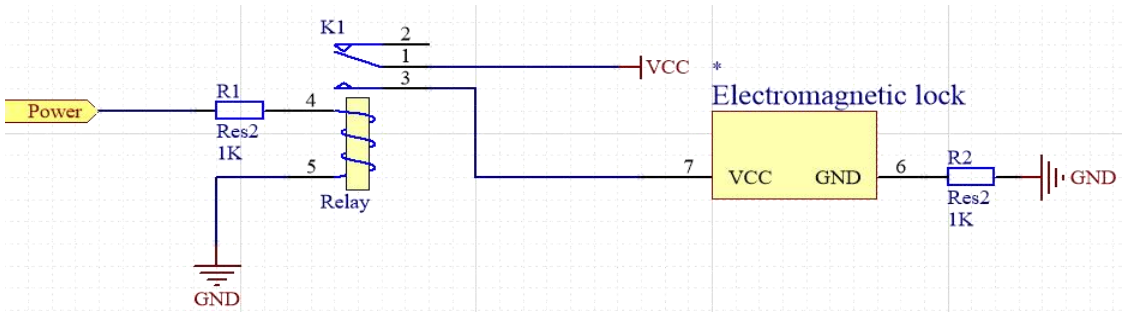

Figure 8 Working circuit diagram of electromagnetic lock

Only four wires are needed to connect the HC05 Bluetooth module and the control core STC15W202S single-chip microcomputer: VCC, GND, TXD and RXD. The specific circuit diagram is shown in the Figure 7. The VCC is connected to the 5V voltage of the power supply module, the GND is grounded, TXD connects with P3.1 of single chip microcomputer and RXD connects with P3.0 of single chip microcomputer. In order to improve the anti-interference ability, a C4 is added as a decoupling capacitor between the power supply and the GND to absorb noise[7].

3.3.3 Miniature electromagnetic lock driving circuit

The self-floating device described in this paper mainly realizes a series of functions by unlocking the electromagnetic lock to control the locking tongue, and its working circuit diagram is shown in the Figure 8.

When the STC15W202S master chip does not send a high signal, the single-knife double-throw relay is located at foot 2, and the electromagnetic lock is not powered on and cannot work; When the STC15W202S main control chip sends a high-level signal, the electromagnet is

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instantly electrified to produce magnetic force, which attracts the single-knife double-throw relay to close to foot 3. The electromagnetic lock starts to work, put away the locking tongue and automatically carry out a series of next operations.

3.4 Working principle

When the single-chip microcomputer in the aircraft receives the signal of the main control chip, it will control the work of the miniature electromagnetic lock, the miniature electromagnetic lock folds the locking tongue, the compressed trigger spring resets and pushes the receiving cylinder and the connecting cylinder upward, and the connecting cylinder drives the corrugated folding airbag, the first support frame and the second support frame to extend upward at the same time, so that the barrier limit of the inner side wall of the storage slot to the reflector is released. The reset of the compressed inflatable spring promotes the extension of the corrugated folding airbag, the internal space of the corrugated folding airbag increases and the pressure decreases, and the external air enters the corrugated folding airbag through an one-way valve to ensure pressure balance. At the same time, the one-way conductivity of the one-way valve avoids the gas leakage inside the corrugated folding airbag, which makes the inside of the corrugated folding airbag full of air and the volume increases. The increase of the volume of the corrugated folding airbag increases the buoyancy of the aircraft, so that the aircraft can float on the sea surface without sinking.

3.5 Creativity

3.5.1 Increase buoyancy

When the aircraft working at sea falls into the sea due to adverse environmental factors, if it is not dealt with in time, it will cause the aircraft to sink into the sea and cause difficulties in recycle due to the gravity of the aircraft itself. Therefore, the self-floating device takes buoyancy as the starting point to improve the recycle rate by increasing the buoyancy of the aircraft.

The device is provided with aircraft roof, corrugated folding airbag, storage slot, installation cylinder, miniature electromagnetic lock, bottom cylinder, storage cylinder, connecting cylinder, trigger spring, one-way valve,the first support frame, the second support frame and inflatable spring, which can increase the buoyancy of the aircraft through the expansion and suction of the corrugated folding airbag when the aircraft is blown down into the sea by strong wind, so as to prevent the aircraft from sinking to the bottom of the sea and facilitate recycle. The pollution to the environment is avoided and the economic loss is reduced.

3.5.2 Improve the quality

Through the corrugated folding airbag, the one-way valve, the first support frame, the second support frame, the inflatable spring and the reflector, the self-floating device can make the expansion of multiple corrugated folding airbags independent of each other. It ensures that when one corrugated folding airbag is damaged, it will not affect the extension of other corrugated folding airbags, and the device can still work and improve the quality of the device.

3.5.3 Reflect light

When the spherical aircraft falling into the sea floats on the sea surface after the expansion and suction of the corrugated folded airbag, the spherical aircraft is not easy to find because of its small size. In order to solve this problem, the device is equipped with a reflector, and the ejection

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of the corrugated folding airbag will also eject with the reflector. When the spherical aircraft floats on the sea surface, it can use the reflector to attract attention, which is convenient to locate and salvage the aircraft.

4. Conclusion

This paper takes the aircraft is prone to fall into the sea and make recycling difficult due to unfavorable environmental factors such as collisions and strong winds during the process of offshore operations as the starting point,presents a self-floating device with miniature electromagnetic lock as the core, and introduces the specific composition, structure, core circuit, working principle and creative points of the device.The device has the advantages of simple structure, flexible application, low cost and easy operation, and has good popularization and practical value.

Acknowledgments

Fund Program:2021 China University of Petroleum (East China) College Students' innovation Training Project "Creative Aircraft Design" (202108029)

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