Research on the Collision Threat of Drones and Civil Airliners

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Abstract

With the rapid development of the UAV(unmanned aerial vehicle) industry, the impact on the operational safety of civil aviation has become more prominent. The impact of drones and civil airliners will be another noteworthy event after the bird collision. This article describes the domestic and international research on drone impact aircraft, drone operation regulations, drone material selection and anti-noise The machine device proposes some rational solutions to the hazards of drones to civil aviation passenger aircraft.

Keywords

Drone, civil aircraft , crash, UAV operations.

1. Introduction

In February 2017, four drone incidents were discovered at Kunming Airport.One of the most serious drones is only 50-70 meters away from civil aviation passenger aircraft.In April of the same year, due to drones at Chengdu Shuangliu International Airport, flights from Chengdu Shuangliu hundred flights were reduced, returned or delayed. In August, drones invaded Changsha Huanghua Airport Clearance Area, affecting 13 landings. In November, a UAV collided with a passenger aircraft in Canada and the wing of the aircraft collided. The statistics of foreign drones and passenger aircraft were close to each other in danger. The collision occurred between 2014 and 2016, and there were 24 cases.In the past 5 months, such incidents occurred as the number was close to the sum of the previous two years. With the development of drones, the issue of potential civil aviation safety and economic losses of drones during the take-off and landing phases of the drones has become increasingly prominent.

However, so far, due to the lack of data analysis for the hazards caused by the operation of drones, it is difficult for us to provide necessary data support for the Civil Aviation Administration of China(CAAC) to specify airworthiness regulations, policies and regulations. The problem of collision between drones and civilian airliners is imminent, and many foreign scholars have conducted research and analysis on them.Do not number your paper: All manuscripts must be in English, also the table and figure texts, otherwise we cannot publish your paper. Please keep a second copy of your manuscript in your office. When receiving the paper, we assume that the corresponding authors grant us the copyright to use the paper for the book or journal in question.

2. Research on the Collision of Drones

On August 15, 2011, the first instance of a collision between a drone and an aircraft occurred in the history of world aviation. A fixed-wing drone collided with a C-130 military transport aircraft. The impact location was seen on the left side of Fig. 1. The leading edge of the wing causes the left wing to leak oil.

This incident is another issue worthy of attention of scholars after the collision of civil aviation with safe operation.

Fig.1 The world's first case of drone collision

2.1 Study on UAV Collisions Abroad

2.1.1 Data Analysis

Bard College conducted statistics on U.S. airspace incidents from 2013 to 2015 on drones and passenger aircraft. More than 90% of incidents occurred in 400ft or more [1]. However, currently there are few data on friction between drones and passenger aircrafts, and it is impossible to perform effective data statistics on them. In order to solve the problem of lack of data, the use of bird hit data to replace drone data is proposed.

The Kinetic Energy Theorem shows that the quality of drones is similar to that of birds, and the speed of drones or birds compared with the speed of civil airliners is very small. The velocity can be approximated by the speed of passenger aircraft, which is known from the kinetic energy theorem. The kinetic energy generated by the drone strike is close to the kinetic energy generated by the bird strike. This can be used to replace the drone strike situation with the bird collision event data, thereby solving the problem of insufficient data.

Exponent [2] used bird strikes to replace drones and FAA bird strike data. It was concluded that drones weighing less than 3 pounds would not cause flights within 5 m from the airport and less than 400 ft. The probability of collision with the passenger aircraft becomes greater.

2.1.2 Simulation Study

In order to predict the impact of a drone hitting a passenger aircraft on a passenger aircraft impact, Virginia Tech University’s Aerospace Structures and Hybrids (CRASH) Lab [1] [3], researchers passed In general, the position of the bird hitting the impact, the location of the general collision of the drone, the finite element analysis method for the simulation of numerical simulation of the drone impact passenger aircraft, to understand the impact of the drone impact on the aircraft collision due to the impact of different positions of the aircraft . It found that the aircraft’s potentially dangerous systems were the radome, the windshield, the front exterior of the cockpit, and the leading edge of the wing and tailplane. If an engine at the rear of an engine is hit by a drone on its wing or cockpit, there is a high probability that debris will enter the engine.

2.1.3 Data and Semi-Empirical Models

Monash University [4] (Monash University) used the published data and semi-empirical model to analyze the impact of drones and civil airliners through the FAA penetration equation, resulting in a 0.75 probability drone entering one of them. Engine, engine thrust reduction or engine failure can be considered as non-catastrophic events; air collision prediction with an impact velocity above 200kts will penetrate the fuselage, regardless of the size of the drone, related to the location of the impact; In the near future, colliding with a large drone may cause the passenger plane's fuselage and windshield to penetrate.

2.1.4 Experimental Study

Prof. Ian Horsfall and his team at Cranfield University in the UK produced a projectile that mimics the physical characteristics of drones[5]. The size and weight of drones are the same as those of conventional drones. As shown in Fig. 2.

Fig.2 Simulated drone hit aircraft experiment device [5]

The experimental results show that the impact of a projectile imitating a drone can penetrate the radome, but under the same weight, the simulated bird impact will bounce back. The bird [3] is composed of organic materials, and 50% of the body is composed of liquids. The drone consists of metal, plastic, and carbon fiber. Compared with the soft tissues and muscles of birds, the drone material is more dense in structure. Hardness is also much stronger.

According to the impulse equation and the momentum equation, under the same conditions, the drone collides with the passenger aircraft. The drone's elastic modulus is relatively low, the buffering time is shorter, and the time for momentum reduction is shorter, so the impulse will be greater, that is, Impact is more effective than bird strikes of the same quality. This is why birds can easily be crushed by rotating blades after being caught in an engine, and some drones can penetrate the engine. And there is a lithium battery inside the drone. If it enters the combustion chamber of the engine, it is easy to burn, and the consequences will be very serious [6].

2.1.5 FAA Research Report

In 2017, the FAA issued a final report on the assessment of the severity of ground crashes in UAV systems [7] and an assessment report on the severity of air impact in UAV systems [8] against the impact of drones crashing into ground and air. In different locations on the body, manned aircraft and drones were numerically simulated.

2.2 Domestic Research on UAV Collisions

2.2.1 Research on Software Simulation

Using the finite element analysis method, the Civil Aviation Flight University of China used the same initial conditions to simulate the drone's impact on the critical parts of the airliner (engine, windshield, wing leading edge).

The impact of the impact velocity on the deformation of the fan blade is almost zero when the drone hits the engine fan blade in the range of 180 to 250 m/s, while the factors affecting the fan blade's rotational speed under high power and low power are obvious. The deformation of the blade impacted by the drone at 100% rotation speed is 2 to 3 times the speed at 30% rotation speed. Because the fan blade strength varies with the leaf height, the drone impacts the tip of the fan blade resulting in the greatest deformation of the blade, followed by the middle of the blade and the smallest blade root. The source of damage caused by drone hitting the blade is mainly from the internal hard lithium battery, which reflects the characteristics of the lithium battery's own material and sturdiness in impact dynamics. At the same time, the good performance of the UAV composite material casing can consume part of the impact energy, thereby reducing the damage to the fan blades. see Fig. 3.

In the viscoelastic model, the drone hits the windshield. The greater the speed, the greater the deformation of the windshield. Under the same conditions, compared with the impact of a bird of equal quality, the deformation caused by the drone impact on the wing is greater and more serious.

The drone strikes the leading edge of the wing, and the damage caused by the collision at three different speeds is very different. The wing speed is caused by the impact velocity of 180m/s. The wing skin is torn by the impact velocity of 220m/s and the wing is severely deformed. At a speed of 250m/s, the drone tears and penetrates the wing skin into the interior. Under the same impact conditions, the destructive force caused by the drone impact is greater than that of an equal mass bird striking the wing.

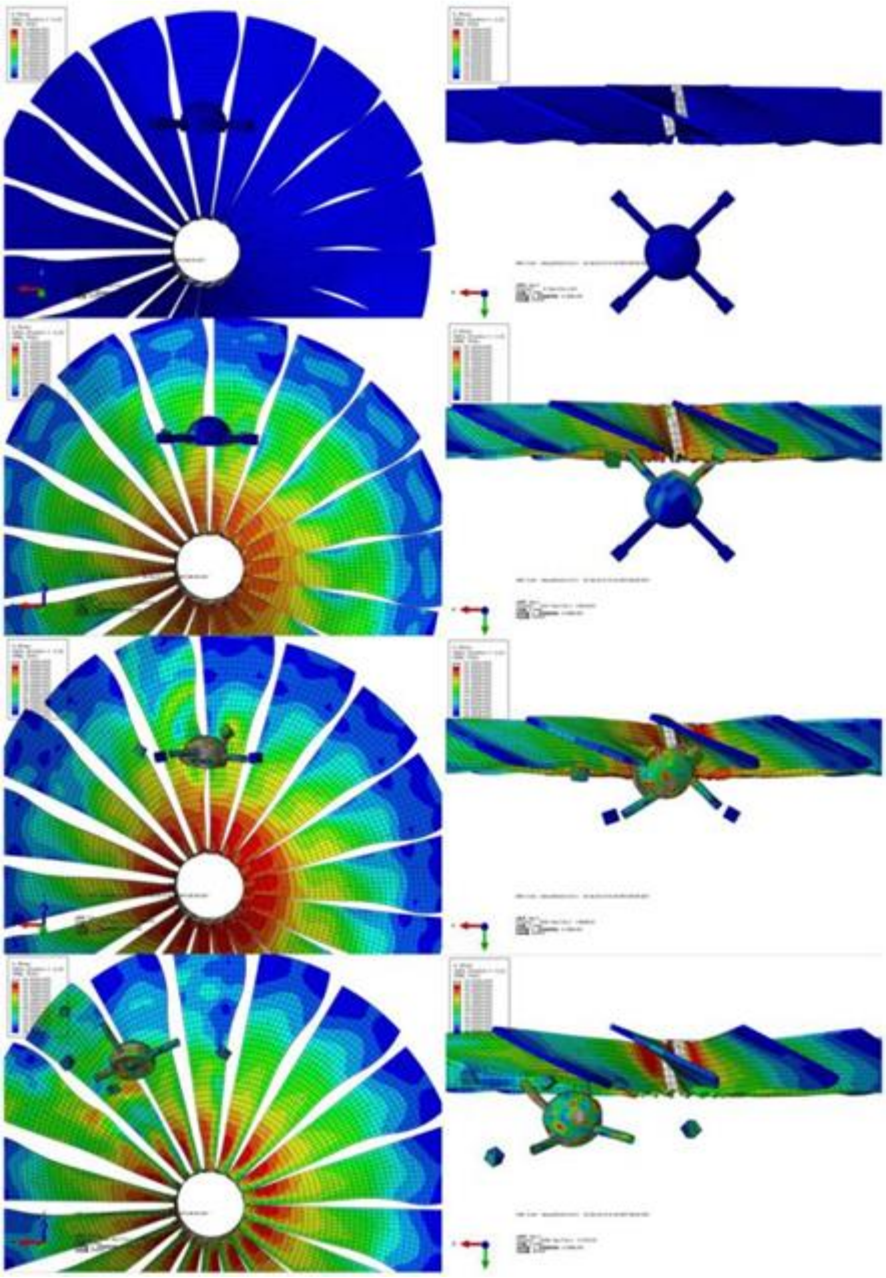

Fig. 3 UAV hits the engine blade facing (left) and looking down (looking down) time history

2.2.2 Research on Collision Experiments

The CAAC took the lead on November 30, 2017 at the Yubei Experimental Base of the Aviation Industry [9] and conducted the first test of collision events between drones and passenger aircraft. It compares the results of collision software with drones and civil airliners, analyzes drone speed, material, quality, attitude, and collision points with the aircraft, and improves the basis for the manufacture and operation of drones. see Fig. 4.

Fig.4 The first collision Test between UAV and Civil Aviation passenger aircraft [9]

3. Solution

Through the above studies, it is found that the dangerous degree of a drone hitting a dangerous passenger aircraft is more dangerous than that of a bird collision. Therefore, the problem of safe operation of civil aviation will become increasingly prominent with the development of the drone industry, and effective collision avoidance measures are proposed. The development of the civil aviation and drone industry is very important, so as to introduce the existing and improved problems of drone collision from the perspective of technology and public opinion.

3.1 Geo-fencing

Geo-fencing [10]: Prevent civilian unmanned aerial vehicles from flying into or out of specific areas, drawing their regional boundaries in the corresponding electronic geographic scope, and cooperating with the flight control system to ensure the regional security of the hardware and software systems. The geofence system uses this software to limit the UAV's flying operation system. The current drone geofence model can be divided into three types based on the horizontal projection geometry:

1. Civil Aviation Airport Obstruction Limits;

2. Sector shape;

3. Polygons.

The restrictions on civil aviation airport obstacles are shown in Fig. 5. The limits for the protection of civil aviation airport obstacles are shown in Fig. 5: A1-A2-C2-arc C2B2-B2-B3-arc B3C3-C3-A3-A4-C4-arc C4B4-B4-B1-arc B1C1-C1-A1 The coordinate of each point and the arc connection range; the arc radius is 7070 m. The top height (relative height) of these faces is 120 m. The range of red polygons in Figure 4 is the scope of civil aviation airport obstacle protection.

For example, China’s Dajiang UAV[11] has installed its drones, entered the no-fly zones and restricted-height zones of various airports into the system, and only by obtaining permission from the relevant authorities to fly in this region can the In addition to the unlocking of regional geofences, in addition, drones are difficult to take off in this area, thereby preventing drones from entering the airport and affecting the operation of civilian airliners. The system can be updated automatically to facilitate flight operations. In the flight process, the state of the airspace will always be alerted, allowing the drone operator to be aware of the status of the flight airspace.

3.2 Drone Cloud System

The drone cloud system (abbreviated as drone cloud) [12] refers to a light and small civil drone operation dynamic database system, which is used to provide drone users with navigation services, meteorological services, etc., and to run civil drones. Data (including operational information, location, altitude, speed, etc.) is monitored in real time. The drone that accesses the system should immediately upload flight data. The drone cloud system has an alarm function for drones that invade the electronic fence. By using this system, UAVs can be monitored and managed, which can play a positive and effective role in the safety of civil aviation operations.

Currently, U-Cloud, U-care, and the UAV flight safety system GEO are operating to obtain approval from the Civil Aviation Administration, and the CAAC puts forward the "Drone Cloud System Interface Data Specification," but in terms of uniform standards and immature technology, For further study.

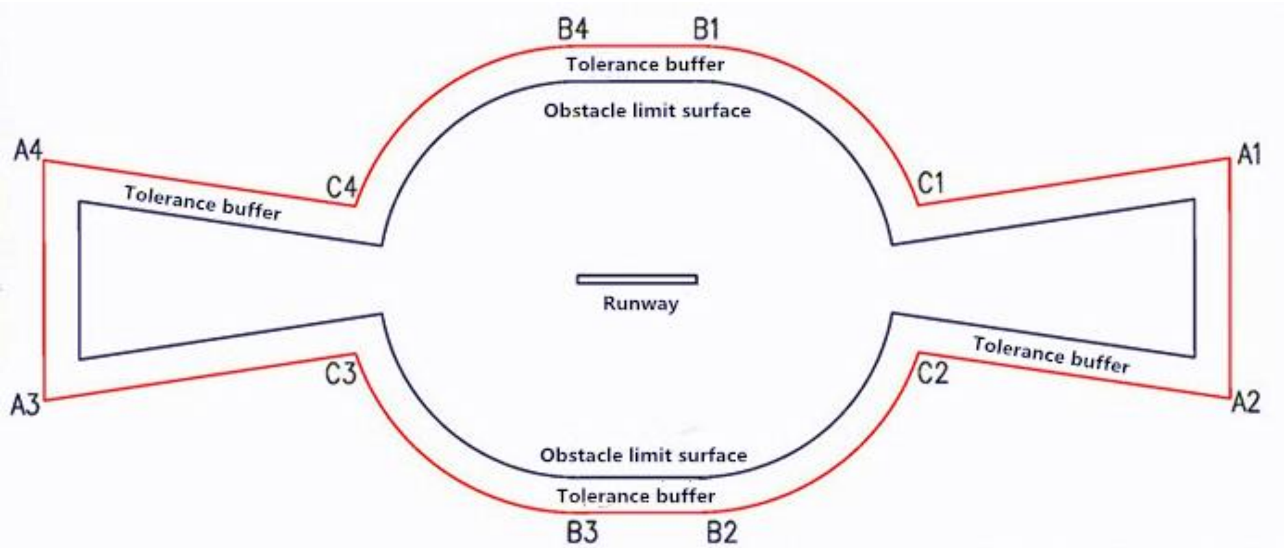

Fig.5 Civil aviation airport obstruction surface protection range and boundary points [10]

3.3 Drone Trap

For uncontrolled or illegal drones can be captured, for example, a UAV aerial trap developed by the United States [13] specifically for capturing illegal drones. Its volume is larger than the average drone. It can lock the unmanned aircraft flying in the air, launch a large net like a missile, and capture the drone back to the ground. In the same way, Russia [14] launched a shoulder-mounted anti-UAV device driven by compressed gas, launching a mesh trap to capture UAVs and equipped with parachutes to ensure that UAVs can land well on the ground.

3.4 Increase Supervision and Public Education

For the UAV which needs the real name registration, the real name registration [15], through the UAV cloud system and the electronic fence technology, the stipulation related no-fly zone, the restricted area and so on, completes the technical good supervision work. For UAV operation specifications and operational provisions further elaboration, The UAV operator shall issue the "measures for the Administration of operational Flight activities of Civil unmanned aerial vehicles" issued by the Civil Aviation Administration, the consultation notice on the "provisions for the Operation of small and Light UAVs", and the "Registration of Real name system for Civil unmanned aerial vehicles" Management regulations, such as operational regulations and UAVs to learn about civil aviation safety knowledge. For the situation of illegal flight, how to solve the problem, how to popularize the knowledge of the impact caused by impact, and how to supervise the illegal flight by the whole people. Achieve technical supervision and national supervision, dual-pronged, as far as possible to avoid drone illegal operation.

4. Conclusion

With the development of the unmanned aerial vehicle industry, the unmanned aerial vehicle operation management should pay more attention to the unmanned aerial vehicle operation management, which can reference the collision between the unmanned aerial vehicle and the passenger aircraft : more than 400ft , more serious accidents can be made , and the result of the collision of the passenger aircraft engine and the windshield is more serious . In the aspect of technical angle and mass education , the unmanned aerial vehicle traffic management scheme is avoided , and the unmanned aerial vehicle traffic management scheme is also expected to be developed in the future , and the air space can be shared with the passenger aircraft , namely , the safety and the economic maximum can be guaranteed .

Acknowledgements

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