RESEARCH ON AIRCRAFT TEST METHODS BEFORE SHIPMENT TO THE CUSTOMER

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Summary: The development of the aircraft has successfully realized the dream of human flight. But operating aircraft is a dangerous activity, any minor problems will cause serious consequences, which requires each new aircraft have to be applied to a comprehensive series of tests before shipment to the customer. This paper briefly introduces the test process of aircraft before shipment, lists different aircraft test methods, summarizes the important significance of the test to the aircraft producing, and looks forward to the development of aircraft test in the future.

Keywords: Flight test, Auxiliary Power Unit, Test Methods, First Flight, Aircraft Production.

Flight test is not only an important means to break through key technologies and verify key systems [1], but also an important verification process to provide decision-making basis for new aircraft production and a necessary way to explore experience for new aircraft to be put into use [2]. It runs through the whole process of aviation basic research, application technology research and user use verification. Developing and improving the level of flight test technology plays an irreplaceable role in improving the level of national aviation scientific research, aviation industry ability and aviation equipment development.

In a broad sense, test flights are both the end of production and the beginning of the development of new aircraft [3]. The experience and practice of the development of the world aviation industry show that without a strong and complete test flight capability as the foundation, there will be no development of the aviation industry, let alone the launch of more advanced technology aircraft. The so-called complete test flight capability is not only the ability to conduct "development and appraisal test flights", but also the ability to conduct "scientific research test flights". In order to independently develop world-class large aircraft and become a world aviation power, it is necessary to have a complete and powerful test flight capability.

Routine Aircraft Test Process.
After the general assembly of the aircraft is completed, it cannot take off immediately, the aircraft will be sent to the factory test shop for a series of flight tests.
on the ground and in the air. First, various tests should be carried out on the ground. That is, the aircraft is loaded with hydraulic pressure and charged with electricity, and the pilot piloting the aircraft simulates the flight state. After all the tests are completed, the plane will make its first flight, known as the "maiden flight". The complexity of this stage is 10-20% of the total complexity of aircraft production.

After the landing gear is installed, the airtight test and rain test are performed, which is a check of the airtightness of the aircraft structure. After the experiment, soundproof cotton, conduit and cable will be installed, and system integration and APU installation will be completed. Auxiliary Power Unit (APU) refers to a small auxiliary power unit that independently outputs compressed air or provides power except for the main power unit (engine) on an aircraft. The APU's role is to provide power and compressed air independently to the aircraft (some just provide electricity), and a small number of APUs can provide additional thrust to the aircraft.

Then install the engine and carry out the pressurizing test, the electrified test and the full-fuselage static test. Static test is one of the contents of structural test, so as to observe and study the strength, stiffness, stress and deformation distribution of aircraft structure or components under static load. It is an important means to verify the correctness of aircraft structural strength and static analysis. In simple terms, the wing is lifted up to see how much force it can withstand. After painting the whole aircraft, main flight control system debugging is carried out. With the development of general aviation industry, general aircraft are gradually installing a large number of integrated avionics systems. The integrated avionics system has advanced functions and high reliability, but the system is relatively complex, especially the integrated design idea, which makes the avionics system has many difficulties in deep maintenance.

Finally, the system function test will be carried out, including landing gear retraction test and RAT assembly. RAT (abbreviation of ram air turbine), is a small emergency wind turbine installed in the belly of a large passenger aircraft, and its size is equivalent to the propeller of a small aircraft. Its function is to provide emergency power for the aircraft to maintain control after the engine stops or the fuel is exhausted, APU starts, engine ignition and technical taxiing. Large aircraft can only be launched after low, medium and high-speed taxiing tests, which is the last step before take-off. Of course, there are also high sliding lifting wheels and reverse thrust experiments. After the test is completed, it is towed back to the hangar for shipment [4].

Test Methods for Civil Aircraft.

Rejected take of test. Rejected take of test, or RTO for short, is one of the most rigorous tests for aircraft to obtain airworthiness certification. The aircraft will face the most severe conditions that may occur, such as complete wear of the brake, reaching the maximum take-off weight of the aircraft, and prohibiting the use of the thrust reverser.

In the RTO test, most of the kinetic energy of the aircraft will be converted into thermal energy by braking, which may lead to the melting of the fusible tire latch and the leakage of the entire tire. In this test, a small brake fire is acceptable, but it must be ensured that it will not spread to the whole airframe within 5 minutes, because this is the shortest time for the airport fire department to arrive.
Stall test flight. Stall test is an important test with great significance. The stall speed determined by stall test flight, as the reference speed of the aircraft, determines not only the speed range of safe flight of the aircraft, but also the service performance and flight quality of the aircraft. It is the first reference data to be determined in aircraft design [5].

Crosswind flight test. Cross wind resistance is a very important performance of aircraft. Strong crosswind will seriously affect the take-off and landing of aircraft. The aircraft can safely take off and land under crosswind meteorological conditions, which must be verified by test flight [6].

Natural icing test flight. The natural icing flight test is to test the anti-icing and de-icing functions of the wings, windshields, engine nacelles and other parts of the aircraft. It is a very important and risky verification subject in the civil aircraft type certification flight test [7].

Splash test. The purpose of the water splash test is to test the performance of the aircraft on the wet runway in rainy days and to ensure that the rain on the fuselage and the raindrops splashed from the main landing gear will not enter the engine and cause the engine to shut down [8].

Maximum brake energy certified test flight. The test flight requires no less than the maximum take-off weight. If the take-off is interrupted after accelerating to the maximum braking energy, the plane may burst into a tire fire or run off the runway, which is a high-risk subject.

Bird strike test. The impact consequences of birds and aircraft can be divided into direct effects and indirect effects.

In terms of direct effect, modern aircraft are generally thin skin structures, and most of the fuselage and wing skins will not exceed 2mm. Although the overall bearing capacity is very strong, bird impact is a local impact load. It is estimated that when a 1kg bird impacts the structure at a speed of 500km/h, the peak impact load will reach more than 20t, and the structure directly impacted by the bird will often have local large deformation or even damage, in serious cases, the aircraft will lose the ability to complete the task [9].

In terms of indirect effects, when local structures are damaged, equipment or systems installed at relevant parts of the structure may become invalid, thereby threatening flight safety. Especially when the engine sucks in birds or collides with large flying birds, it may cause the engine blades to be thrown out. The high-energy debris thrown out may break through the engine casing, or even continue to damage the engine body after breaking through the casing, leading to serious accidents.

Tail rubbing test. Also known as the minimum take-off speed test, the pilot is required to determine the minimum take-off speed of the aircraft under different configuration conditions. Because the take-off speed of the aircraft from the runway is basically lower than expected, the tail is likely to collide with the ground and cause accidents, so this operation is difficult for pilots.

Lightning Test. Although it sounds worrisome, commercial aircraft are struck by lightning every day. In fact, most aircraft fuselage is made of conductive aluminium materials. When the aircraft enters the storm cloud, a large amount of static electricity will be collected and released [10]. However, due to strict aviation regulations, all aircraft must have the function of electrical shielding to ensure that the interior of the aircraft is protected from lightning.
**Extreme weather test.** Extreme weather test generally refers to the test that the aircraft must accept under the conditions of high temperature, low temperature, wind, rain and snow. The purpose of this test is to ensure that the engine, materials and control system of the aircraft can operate normally under extreme weather conditions. In addition, the aircraft will also fly in high altitude and low altitude areas [11].

**Conclusions.** Nowadays, with the increasingly high degree of information technology in modern aviation, there are more and more types of aircraft test data. This helps to strengthen the guarantee of production and delivery of aircraft, and also promotes the development of new aircraft. With the data from a series of tests, we can produce new models with more functions and more power in the future. At the same time, the flight test has entered the era of big data. The arrival of big data for flight test has a strong impact on the traditional technologies and modes of test data acquisition, recording, transmission and processing, and also poses severe challenges. In the future, we need to actively use information processing technology to summarize and process the huge and complicated data in a more effective way, promote the application and sharing of big data for test flights, and better serve the aviation manufacturing industry.

**References:**


