Fault diagnosis method for power system of civil aircraft Assembly site

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Abstract. During the process of producing civil aircraft (On the Aircraft Test Procedure), Whether the electric power system fault can be quickly, accurately and properly diagnosed and closed will directly affect the production schedule and even delay delivery of the aircraft. This paper introduces the diagnosis requirements and methods of power system failure in production field, based on the practical experience, a troubleshooting model is proposed , and has certain guiding function for engineering management staff and liaison engineers.

1. Introduction
In the 1970s, the fault diagnosis technology dominated by analytical redundancy was first developed in the United States. The work of bear at MIT marks the birth of fault diagnosis technology. In his doctoral dissertation, he proposed to replace hardware redundancy with analytical redundancy, and use self-organization of the system to make the system achieve closed-loop stability, and then get the system fault information by comparing the output of the observer. In the early 1980s, the research of fault diagnosis technology was gradually starting in China. In recent years, more and more attention has been paid to the fault detection and diagnosis of the system [1].

From the research results and data at home and abroad, the research on fault diagnosis technology has developed to a more in-depth and mature stage, the theoretical results are numerous. However, compared with the blooming of theoretical research, the application in engineering, especially in civil aircraft production site, needs to be strengthened.

2. Composition and function of power supply system
Civil aircraft power system is compared to the "blood" of aircraft, is one of the main systems on the aircraft, is the necessary guarantee of modern aviation safety. The aircraft power system is to convert the mechanical energy generated by aeroengine into various forms of electrical energy for all electromechanical systems and electronic equipment on board. Aircraft power system generally includes main power supply system, auxiliary power supply system, backup power supply system, emergency power supply system and secondary power supply system. In addition, in order to meet the high reliability requirements of flight control system power supply, a special power supply system is also set up on the aircraft with fly by wire control system. Historically, the power supply systems used in aircraft include low voltage direct current (LVDC), high voltage direct current (HVDC), variable frequency AC power supply, constant speed constant frequency (CSCF) power supply and variable speed constant frequency (VSVF) power supply [2]. With the continuous development and progress of science and technology, the performance of aircraft is improving day by day, and people's
understanding of aircraft power system is also gradually changing. Before 1940s, most aircraft used DC power system, and the rated voltage gradually changed from 6V and 12V to 28.5V. With the increase of the number of aircraft electrical equipment, in the late 1940s, the position of the main power supply gradually changed from DC power supply to AC power supply. At present, constant speed and constant frequency AC power supply system is widely used in large and medium-sized civil aircraft. After more than 50 years of development, the manufacturing technology of this kind of system is relatively mature [3].

3. Basic requirements of power system fault diagnosis
In the production process, the fault of power supply system is generally found in the process of wiring harness conduction or ground machine function test. The functional test to find the fault may be the power supply system, or the communication, navigation, flight control and other systems crosslinked with the power supply. All fault diagnosis methods are proposed to improve the accuracy of fault diagnosis, reduce false alarm and missed alarm, and infer the order and location of fault, and estimate the impact of fault. Therefore, the troubleshooting requirements mainly include: fault recurrence, accurate positioning, clear mechanism, effective measures, and consideration of cross-linking [4]. In the process of production test, when the fault characteristics appear, the engineering and technical personnel can not blindly grasp a certain feature point to analyze, and then simply and extensively based on experience or one-sided analysis to formulate troubleshooting measures, but should gradually carry out troubleshooting according to the requirements. Scientific and effective troubleshooting method is based on rich professional knowledge reserves and practical experience, and is still carried out in strict accordance with the prescribed procedures. Only in this way can we put an end to the non-standard troubleshooting process and lay a solid foundation for rapid, accurate and standardized troubleshooting.

According to the author's years of work experience in the field, the troubleshooting of power supply system mainly follows (but not limited to) the following requirements:

(1) Fault recurrence. When the production site reports the fault to the engineering and technical personnel, it is necessary to ensure that the fault can recur. In case of fault recurrence, engineering and technical personnel shall confirm whether each link of the test is carried out according to the procedure. To avoid "false failure" caused by unsatisfied test preconditions, which will lead to labor and affect the production schedule[5].

(2) Locate the fault source. Because the power system is more complex and there are many cross-linked systems, when the indication recording system shows the power system fault or the operator reports the power system fault, the engineering and technical personnel should analyze the fault on the basis of recurrence, locate the fault location or range, and reduce the workload of subsequent troubleshooting[6];

(3) The mechanism is clear. According to the fault characteristics and the logic of function realization, the mechanism of fault generation is sorted out in order to draw the cause and effect diagram or fault tree, which is conducive to the formulation of troubleshooting scheme;

(4) The measures are effective. On the basis of the above analysis, practical and effective troubleshooting measures should be formulated instead of "delaying measures", so as to fundamentally solve the problem and put an end to such problems as far as possible;

(5) Consider crosslinking. Since the power supply system supplies power to the electrical equipment of the whole machine, the cross-linking system should be considered from the beginning of fault recurrence. The possible influence of the cross-linking system on the fault and the influence of troubleshooting measures on the cross-linking system are taken into account.

4. Troubleshooting of power supply system
There are many kinds of fault diagnosis methods for power system, but the common methods are similar contrast test, cause and effect diagram, logic diagram, fault tree and so on. But in the production site, according to the actual situation of comprehensive analysis, so as to select the most
appropriate and efficient exclusion method. According to the common experience, the SCFME troubleshooting model is established. The meaning of each letter in SCFME is as follows:

(1) S - Similar contrast test. The fault in the production process is different from the troubleshooting of the aircraft operating on the route. Some faults in the production may be just because the preconditions of the test are not met, the tooling itself is not adjusted to the corresponding mode and the contact is not in good contact. Therefore, when the power supply system fails, the test results of similar channels or equipment will be compared. Similar contrast test refers to two sets of systems or subsystems with the same structure and function. When one of them fails, the test results of the other are used for comparison, or the components are exchanged to see whether the fault will transfer, so it is easier to find out the fault source. For example, if there is a problem with the power supply of one channel, we will compare and test the power supply of the other channel. Similar contrast test is widely used in power supply system troubleshooting in production field [7].

(2) C - Cause and effect diagram. Causality diagram method, namely causal analysis diagram, is also called characteristic factor diagram, Ishikawa diagram or shark fin diagram. It is a kind of tool proposed by Professor Ishikawa of Tokyo University in Japan. It can express the relationship between quality problems and causes through lines with arrows. It is a tool to analyze the relationship between various factors affecting product quality. Causality diagram method is generally used to describe the test method of combination of multiple input conditions, which was first used in software testing. According to the combination of input conditions, constraints and causality of output conditions, the method of designing test cases is designed by analyzing various combinations of input conditions. It is suitable for checking various combinations of program input conditions. Causality diagram method is usually combined with decision table to determine the judgment conditions by mapping multiple inputs that interact at the same time. The final result of causality diagram method is decision table, which is suitable for checking various combinations of program input conditions. Using causality diagram method can help us select a group of efficient test cases according to certain steps, at the same time, it can also point out what problems exist in the program specification, identify and make causality diagram [8].

The causality diagram method is more suitable for analyzing whether the initial conditions of fault recurrence are satisfied, fault location and cross-linked system analysis when fault occurs.

(3) F - Fault tree analysis (FTA) method. Fault tree analysis (FTA) is also called fault tree analysis (FTA). It uses logical method to conduct hazard analysis visually. It is characterized by intuitive, clear, clear thinking and strong logic. It can be used for qualitative analysis and quantitative analysis. The system engineering method is the most important analysis method in safety system engineering. Fault tree analysis starts from a possible accident, looking for the direct cause and indirect cause event of the top event from top to bottom, and then to the basic cause event, and expresses the logical relationship between these events with logic diagram. It is suitable for fault cause analysis and measure making [9].

(4) M - Matrix diagram method. Matrix diagram method is to use the form of matrix in mathematics to express the relationship between factors, and to explore the problem and get the idea of solving the problem. It is a method of multi thinking and analyzing problems. Matrix graph method is to find out the paired factors from the events of multi-dimensional problems, arrange them into a matrix diagram, and then analyze the problems according to the matrix diagram to determine the key points. It is a good method to explore problems through comprehensive thinking of multiple factors. In complex quality problems, there are often many pairs of quality factors. Find out these pairs of factors and arrange them into rows and columns respectively. The intersection point is the degree of their correlation. On this basis, we can find out the existing problems and the forms of problems, so as to find the solutions to the problems [9].

(5) E - Expert system. Expert system is an intelligent computer program which can diagnose faults at the expert level of human beings. It is generally composed of five parts: knowledge base, inference engine, database, interpreter and knowledge acquisition program. Because of its high diagnostic level and high diagnostic efficiency, it is widely used. The faults of the power supply system on the
production site of civil aircraft are complex, but they are also repetitive. Some similar faults [10] will occur repeatedly. There is a certain accumulation of experience and the basis of using expert diagnosis system. The future diagnosis expert system is also an important development direction.

5. Conclusions
This paper mainly introduces the requirements and common methods of power system troubleshooting in the production site of civil aircraft, and puts forward a troubleshooting model based on practical experience, which has a certain guiding role for the management personnel and contact engineers in the production site of civil aircraft.

Compared with a large number of troubleshooting methods, the practical application results of fault diagnosis technology in engineering are very insufficient. With the rapid development of industry and chemical industry, fault diagnosis system has not been widely used in industrial devices. As engineering and technical personnel, we need to continue to make efforts to transform fault diagnosis technology into practical application.

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