Aircraft Composite Structure Static Strength Airworthiness Verification Technology

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Abstract: This paper summarizes the characteristics of composite structure, analyzes the void resistance properties that can be applied to ccara - 25 composite structure, and defines the void resistance requirements of composite structure through material, design, manufacturing and verification. On this basis, combined with the proposed cycle AC 20 - 107b and relevant industry standards, the idea of confirming the void resistance of composite structures is proposed.

1. Introduction

Composite materials have been used in civil aircraft since the mid-1970s. According to statistics, Airbus A320 and A330 composite materials developed by airbus company account for about 15% of the total structural mass, A340 composite materials account for about 13% of the total structural mass and A380 composite materials account for 22%. Boeing B777 composite material accounts for 25% of the total structural mass, and the components used include tail, blade and other structures. Boeing B787 composites account for more than 50% of the total structural mass. Main bearing structure. Composite materials were rarely used in aircraft structures before the 1970s, and the specificity of composite materials was not considered in the original aircraft structure specifications[1]. Considering the differences between composite materials and metal materials, the specifications of aerospace resistance of aircraft structure are also applicable to such products, but many regulations cannot fully cover the safety requirements of composite materials. For this reason, FAA issued consulting yen of composite AC 20 - 107 "composite aircraft structure" for the first time in 1978. Variations. With the continuous accumulation of composite experience and technology development, the fatigue and damage tolerance, continuous air resistance and airworthiness in 1984 and 2009 have been improved. At present, AC 20 - 107b is a relatively complete proof of space resistance for composite structure [2,3]. In the 1990s, composite structures have been applied in China, but the proof of air resistance has not been carried out [3]. ARJ 21-700, C 919 and other aircraft under development, the amount of composite structure is gradually increasing, but it is still in the air proof stage[2]. At present, there is not enough domestic experience in the verification of air resistance of composite aircraft structure, and there is no specific operation procedure and method. This article starts with the idea of space tolerance compliance verification.

2. Structural Characteristics of Composite Materials

Before studying the air resistance of composite aircraft structure, the difference between composite material and metal structure is analyzed. By combining the differences between the two, it is easy to define the requirements for void resistance of composite structures and the idea of verification.

2.1. Different Square Nature

Compared with the isotropy of metal, unidirectional composites show strong anisotropy of high longitudinal strength, elastic coefficient, low transverse shear strength and elastic coefficient. The calculation and analysis of unidirectional composites are more complicated than that of metal

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materials in the manufacturing of composite structures.

2.2. Design Possibilities

The composite structure can be designed as pseudo equal or hetero square, symmetrical equilibrium or asymmetry. This feature brings free design space to realize the design idea that metal materials can't. At the same time, it is difficult to design, analyze and manufacture the structure because of the heterogeneity.

Figure 1 Foreign composite aircraft

2.3. Fatigue and Damage Characteristics

Sensitivity to impact damage

Compared with the equivalent properties of metals, the interlaminar properties of composite structures are much lower than in-plane properties[3]. When large-scale matrix cracking and delamination occur in the interior, the surface can not be detected visually, but its compression bearing capacity is greatly reduced (see Figure 1), which will seriously affect the structural strength and stiffness of the composite.

2.4. Forming Characteristics

Composite materials are mainly formed by automatic pancake, vacuum bag and other methods. Composite structure is the completion of material formation and component forming. Material, design and manufacturing are closely related, and its performance is closely related to manufacturing process. Generally speaking, the composite structure is significantly different from the conventional metal structure in material properties, mechanical properties, failure mechanism, environmental impact, impact damage characteristics, conductivity, process dispersion and other aspects[4]. The verification of void resistance of composite structure can not continue the existing verification method of metal structure. In order to ensure the application of composite structure to achieve the same safety as metal structure, it is necessary to study the verification method of composite structure.

3. Airworthiness Clauses Applicable to Composite Structures

Taking the transporter as an example, the applicable conditions of composite structure are 25.305, 25.307, 25.571, 25.581, 25.609, 25.613, 25.619, 25.629, 25.631, 25.651, 25.783, 25.775, 25.1529, etc. These terms relate to material manufacturing methods, material properties, and strength verification. Impact resistance and fatigue evaluation, aeroelastic stability, lightning protection, continuous air resistance, etc. The following parts 25.305, 25.307, 25.571, 25.581, 25.603, 25.605, 25.609, 25.613, 25.619 and 25.629 can be explained by these terms.

3.1. Strength and Deformation of 25.305

The core can not have "harmful" permanent deformation under ultimate load, and can be maintained for more than 3S under ultimate load[5]. In order to verify the ultimate load and the strength and deformation of various structures under the ultimate load, the verification method of calculation analysis and supplementary test is adopted.

Figure 2 Domestic composite aircraft

3.2. 25.307 Proof of Structural Adaptability

For each critical load condition of the structure, compliance must be demonstrated by analysis or testing. When structural analysis is used to show the compliance of structural strength, it is necessary to verify the accuracy of the method and model through the homogeneous structure verified by experiments. In order to demonstrate the compliance of the new structure, it is necessary to combine the analytical method with the experimental verification.

3.3. Structural Damage Tolerance and Fatigue Assessment of 25.571

According to the damage tolerance and fatigue requirements, the composite structure is designed to determine the damage location and shape to ensure no destructive damage[6]. Sound fatigue cracking and destructive cracking will not cause destructive damage. Sufficient full scale fatigue tests show that large-scale fatigue damage will not occur during the design life of the aircraft; it can meet the requirements of discrete damage, lightning stroke and rotor burst.

3.4. 25.581 Lightning Protection

The composite structure must be combined with the lightning strike area of the structure to protect the lightning strike. It should take acceptable shunt measures so that the generated current can be used for misappropriation without endangering the aircraft. The lightning damage should be introduced into the lightning resistance test according to the results of the lightning resistance test.

Table 1 Main parameters of aircraft

Name	Numerical value	Company
Maximum takeoff weight	1999	kg
Wing length	13.43	m
Wing reference area	16.29	m^2
Aerodynamic chord length of wing	1.281	m
Aspect ratio	11.1	

3.5. Materials of 25.603

The suitability and durability of materials shall be determined by tests or experience. It usually refers to mature materials that have been tested by airlines for a long time, or materials that have accumulated a certain amount of test data after testing. When the selected material is outside the "approved" range, relevant tests are necessary and the test results will be reported to the air resistance authority for approval. Composites are very sensitive to ambient temperature and humidity. In performance evaluation, the influence of ambient temperature and humidity must be considered.

3.6. Manufacturing Method of 25.605

At the same time, composite materials and structures are formed. The stability of manufacturing process has an important influence on material properties and product quality. The manufacturing method used must be able to consistently produce structures that are often intact. The new process needs to be tested and verified. Among them, the process specification and test outline need to be approved by the anti air agency, and the management personnel shall conduct on-site visual inspection during the test and verification process.

4. Verification Idea of Composite Structure

In addition to the above provisions on air resistance, AC 20 materials and manufacturing, structural verification (static capacity, fatigue / damage tolerance), continuous air resistance, other (fallibility / bird strike / emergency, fire / flame retardant / other thermal issues, lightning protection) [6] four types of verification required subtypes. In this chapter, the main purpose is to give the following ideas for verification.

4.1. Material and Manufacturing Confirmation

At the heart of the validation idea are tests and data that are sufficient to demonstrate the qualification, repeatability, reliability, and safety of materials and processes. According to the test statistics, considering the expected adverse environmental conditions, the allowable value is determined to minimize the structural damage probability caused by material property deviation[7]. Use "approved" composite systems as much as possible, or select new materials with sufficient test data accumulation. Establish specifications covering materials, material handling and manufacturing processes to ensure consistency of materials and processes.

4.2. Fatigue and Damage Tolerance

The core is to ensure that destructive damage caused by fatigue, corrosion, manufacturing defects or occasional damage is avoided throughout life. Before the damage (or failure) is detected, the damaged structure ensures the appropriate residual strength and rigidity to ensure the continuous safe use of the aircraft. The influence of composite properties on fatigue, corrosion resistance and damage should be fully considered, and the influence of composite materials on the fatigue properties of undetectable defects, allowable manufacturing defects, bvid (open hole impact damage) and environment should be considered. In order to make defects, the threat of damage may occur between use or maintenance (low tools, hail, sand, rock, strike impact, lightning, birds, etc.), the major discovery and strength of damage is the first must to be evaluated, and the corresponding database is the most dangerous loss, which must be established in order to decide[8]. Analyze different types of damage, probability of damage occurrence and inspection interval, inspection method and repair method of relevant residual strength, and analyze whether they meet the requirements of residual strength. The full scale fatigue and damage capacity is used to limit the test results and provide the basis for the preparation of the structural inspection summary. In the fatigue life evaluation, in order to fill the fatigue dispersion of composite structure, the combination of life dispersion coefficient and load amplification coefficient can be used. The damage structure of composite with defects / damage has good fatigue performance (generally, the static strength of samples with the same defects / damage is less than 60%). Therefore, as long as the static strength requirements are met, the fatigue life requirements can usually be met automatically, that is, "static coating fatigue"[9]. In engineering design, the fatigue threshold is usually determined by multiple assemblies, components or test pieces. In the design process, the use of distortion is controlled. The fatigue distortion is below the fatigue threshold, and the fatigue problem is covered by static strength.

5. Conclusion

The air resistance of composite aircraft structure is analyzed, and the air resistance requirements of composite structure based on material, design, manufacture and verification are defined[10]. On this basis, consulting notice and relevant industry standards and combinations, materials and processes on composite material matching verification of creativity, static strength, fatigue and allowable damage, which is the standard provided by the airworthiness verification of composite aircraft structure guide. Secondly, the methods and methods to verify the air resistance of aircraft composite structures are studied.

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