

Li Weiping¹, Zheng Xiaoling¹

Shanghai Aircraft Design and Research Institute of COMAC, Shanghai, P. R. China

This paper analyzes some regulation requirements closely related with composite and proposes a technical road map of the development and verification of composite structure.

1. Regulation compliance analysis.

1.1 Material requirements

Based on the data provided by the material supplier for initial screening, material screening test could be conducted to prepare the draft material specifications. Then, the applicant could implement PCD Audit, material pre-identification for accessing comprehensive material performance data. Based on the data, the first draft of material specifications is established for preliminary design. If the applicant formally submits the type certification application, it is necessary to submit the specification and the data to authority in accordance with the FAR25.603, and prepare the material qualification test plan, carry on the test, form the formal material specification, approve into the QPL. Material specifications and materials that meet the requirements of FAR25.603 can be used for detailed structural design and validation.

1.2 Process requirements

According to the design characteristics of specific structural parts to choose the applicable process methods, the applicant could prepare the process specifications. The parameters in the process specification obtain through element tests, such as composite laminate suction and curing temperature, time and pressure. The porosity and mechanical properties are measured, and the curing process parameters of the materials are determined.

Then, within the requirements determined by the process specification, through the study of the manufacturing process of specific structural parts (including the molding process method, the mold scheme, the process scheme and the forming process of each part), the process procedure of the parts is compiled. In the manufacturing study, pre-part manufacturing (PPM), the thermal distribution test, cutting, mechanism testing and other tests are conducted to optimize a variety of molding process parameters. Synchronously, non-destructive inspection (NDI) the standard block is developed.

Finally, the various formal process specifications and process procedures are established. The applicant submit the certification test plan of process specifications. After certification test, the process specification can be effective and implemented. Then the prepared various types of process procedures and PPM implementation plans are submitted to the authority. Only the results combine with the prediction, a manufacturer can formally produce certain types of parts in accordance with the approved process procedures, thus completing the compliance with FAR25.605.

1.3 Material allowable value:

The typical layups of laminate are selected to test according to the Test Standard of airworthiness approval. The material allowable values (FAR25.613) are obtained on the statistical analysis of testing data, and used for structural design and strength analysis. The results are generally required a comparison with the relevant test data of the material supplier to ensure consistency between the processing process method of the user and the supplier.

1.4 Structural design value

After the material and process is determined, some typical design detail and structural element are tested for design value considering the stable and qualified manufacturing. The results should be approved by authority and the determined allowable value (FAR25.613) for specific details are used in structural design and strength analysis.

2. Test planning of composite main structures

The recommended compliance strategy of composite structure is building block. The development and verification building block could be divided into development tests for design/manufacturing and airworthiness tests for verification.

2.1 Development tests for design and manufacturing

In the development of composite structure, engineering research and development test must be carried out.

1) Material research: material screening and process selection are inextricably linked and must be carried out together. It is the responsibility of the material supplier to ensure that the user has the correct knowledge of the process. The supplier shall provide performance data for the processing of selected materials under the technological conditions of its plant facilities. And the user will process and test the selected materials under the conditions in which they are actually used for production, compare the data, and ensure consistency between the process conditions of the user and the supplier.

- 2) Process research: On the basis of preliminary determination of process specifications, the process parameters are determined through testing. The formal process specifications and NDI specifications are established.
- 3) Pre-Parts Manufacturing: For all kinds of structural parts, the molding process are researched. The mold design and manufacture needs to be studied and controlled. Thermal distribution measurement and cutting test are carried out according to the types of structure configurations.
- 4) Structural parts research and development: This parts contains series of structural parts configuration selection test, including panels (plane and curved plate), stringer, frame, beam and so on. The results are applied for structural detail design and selection, including all kinds of joints and integrated structure details, analysis method research and verification.
- 5) Allowable values and design values: Before the process study is completed, a batch of mapping tests can be carried out for structural design, taking into account a variety of use environmental factors. When the process specification is determined or approved, a comprehensive allowable value test is carried out for detailed structural design and validation.
- 6) Damage tolerance: The load spectrum of composites was compiled, and the low-load truncation value is determined by sample fatigue test. The damage characteristics of various structural parts are researched, including the introduction of manufacturing defects and impact damage. The type, size, location and energy of the damage need to be obtained through test and statistical analysis, and all kinds of damage in service must be covered. The goal is to verify the structural capability of 5 types of damages (BVID, VID, LVID, discrete source damage, abnormal damage) and manufacturing defects of various structural parts. In this process, the acceptance requirement of composite part manufacturing and structural inspection outline are established.
- 7) Repair considering: The repair requirement should be considered to select repair materials, repair process, repair design, repair analysis, repair tolerance, and repair during maintenance through the repair test. All above repair method and strength recovery should be verified.

2.2 Airworthiness verification test

According to the conformity analysis of the airworthiness regulations, the airworthiness verification test is carried out for each clause, and the requirements of AC20-107B are followed. It should pay attention that the strength verification test of composite structure can not only rely on full-scale test. It needs to plan the building blocks of various levels of validation tests according to structural characteristics and process methods. All airworthiness verification tests are subject to approval by the authority, manufacturing conformity inspections, on-site witnesses, approval processes, and eventually obtaining airworthiness approvals for the closure of the terms.

- 1) Materials: The applicant should prepare specifications and invite the authority for on-site PCD audit. During PCD audit, the material qualification test plan should be approved and the test procedure should be witnessed.
- 2) Process: The applicant should prepare process specifications, submit the verification test plan to authority for approval, and conduct process verification test by authority on-site witness.
- 3) Parts manufacturing: For all kinds of structural parts, full-size parts and integral molding structural parts of the pre-production verification Test (PPV). This procedure should invite the authority on-site review. The results should be stable and accepted by the authority.
- 4) Allowable value: After the process specification is determined, the tests of the allowable value are carried out. It is necessary to consider the influence of various environment.
- 5) Structural verification: Validation tests are carried out for each structural detail, typical structural parts, and full-scale structural components.
- 6) Damage tolerance: During the structural validation, it should be verified at the same time that the ability of 5 types of damages identified by each component and the acceptable manufacturing defect/.
- 7) Repair: The repair method for each component (repair material, repair process, repair design, repair analysis, repair allowance) is validated and incorporated into the repair manual, which can be carried out in conjunction with structural verification.

3. Conclusion

Through an analysis of the airworthiness requirements of composite structures, it is concluded that there is sufficient experimental support, controllable manufacturing process, continuous maintenance of proven configuration state is the fundamental guarantee of product quality and stability of composite structural parts, and is also an important prerequisite for the design and manufacture of composite structural parts to obtain approval from the authority. Therefore, it should pay attention to the integrated development ideas of materials, process, design, analysis, manufacture, testing, verification and maintenance of composites, and plan the test tasks of various specialties, according to the building block of development and verification.

Keywords: composite structure, airworthiness compliance, material specification, process specification