Universe Scientific Publishing

DOI:10.18686/ahe.v7i27.10510

A Brief Discussion on Structural Damage and Detection and Maintenance Methods of Aircraft Composite Materials

Yinghai Zhou

Shanghai Civil Aviation College,Shanghai,201300,China

Abstract: With the development of aviation industry,the application of aircraft composite structures is more and more extensive. The composite structure has the characteristics of light weight and high strength,which plays an important role in improving the performance and economy of aircraft.However,composite structures are also vulnerable to damage,such as cracks,delamination,fatigue,impact,etc.In order to ensure the flight safety and prolong the life of aircraft structure,it is necessary to study and apply the damage detection and maintenance methods of aircraft composite structures.In this paper,the classification and causes of structural damage of aircraft composite materials are discussed,and the methods of damage detection and maintenance are discussed.

Keywords: Aircraft composite material;Structural damage;Inspection and maintenance method

Aircraft composite structure has become an important part of the modern aviation industry,replacing the traditional metal structure,with its light weight,high strength and good corrosion resistance and other characteristics are widely used.However,due to the complexity and particularity of the composite structure,it is vulnerable to various damages,such as surface damage,internal damage and structural fatigue.In order to ensure the safe operation of the aircraft,these damages must be detected and repaired in a timely manner.This paper first introduces the classification and causes of structural damage of aircraft composite materials.Then,focus on the visual inspection,touch inspection and non-destructive testing technology,including ultrasonic detection,infrared thermal imaging and optical fiber spectrum technology applications.Finally,this paper will also discuss the maintenance methods of aircraft composite structures,such as surface repair,component replacement and composite patching.

1. Overview of aircraft composite material structure

1.1 A Brief Introduction to the structure of the aircraft composites

Aircraft composite structure refers to the use of one or more composite materials(such as carbon fiber,glass fiber and organic)as a matrix,reinforced by reinforcing materials(such as fabric or yarn)of structural members.Compared with traditional metal structures,aircraft composite structures are lighter,stronger and more rigid,so they have been widely used in the aviation industry[1].

1.2 Classification and causes of Damage of aircraft composite structures

Aircraft composite structures are faced with various types and causes of damage.Firstly,according to the nature and form of damage,the damage of aircraft composite structures can be divided into surface damage and internal damage.Surface damage mainly includes scratches,wear,dents and diffuse reflection.These injuries are usually caused by external physical factors,such as impact,rubbing,fatigue or acid and alkali corrosion.The internal damage mainly includes cracks,delamination,holes and bubbles,etc. These damages may be caused by defects in the structure during the manufacturing process of the composite material or by stress and thermal load during use.Secondly,the damage of the aircraft composite structure can be classified according to the cause of the damage. On the one hand,there are external physical factors,such as mechanical impacts,foreign objects,severe vibrations or aerodynamic shocks at high speeds.These factors can cause damage to the surface of the structure such as fragmentation,scratches or dents.The other is internal factors.In the manufacturing process of composite materials,defects of aircraft structural materials may occur,such as gaps or inhomogeneity between fiber fabrics,poor resin penetration,etc.These defects may cause internal damage such as fiber fracture,delamination or holes in the structure.In addition,aircraft composite structures are susceptible to environmental factors such

as UV exposure,temperature changes,humidity and chemical media.These factors may cause aging,embrittlement and degradation of the structure

2. Aircraft composite material structural damage detection method

2.1 Visual inspection and touch inspection

Visual inspection is to observe and check the surface of the composite material structure for visible damage,such as scratches,cracks and depressions.This detection method is simple and direct,without special instruments and equipment,and can be widely used in aviation maintenance field.During a visual inspection,inspectors take a close look at the surface of the composite structure and use lighting to enhance the visibility of damage.They will look for any abnormalities or signs of damage on the surface,such as color changes,irregular appearance,cracking or misalignment of visible fibers,etc.Visual inspection can also be done by using a magnifying glass or microscope to check for minor damage in order to more accurately assess the integrity of the structure.Compared with visual inspection,touch inspection can assess the damage of composite structures more comprehensively.By gently touching and scanning the surface of the structure,the inspector can sense surface irregularities or anomalies and determine possible damage.The advantage of touch inspection is that it can detect some small or subtle damage that visual inspection cannot detect,such as tiny cracks,local dents,or delamination.Through touch inspection,inspectors can sense changes in the hardness,roughness or roughness of the damaged area,so as to judge the health of the structure.Visual inspection and touch inspection as part of the aircraft composite structural damage detection method,for maintenance personnel to provide rapid initial damage assessment and location.However,these two detection methods alone cannot determine the depth,severity,and potential impact of the damage,so it is often necessary to combine other NDT techniques in actual testing for more accurate assessment and diagnosis.

2.2 Nondestructive testing technology

Nondestructive testing technology plays an important role in the structural damage detection of aircraft composite materials. Among them,ultrasonic detection,infrared thermal imager and fiber spectrum technology are commonly used non-destructive testing technology.Ultrasonic inspection is a method to detect internal damage by introducing ultrasonic waves into the structure of composite materials.Changes in the propagation speed and energy of ultrasonic waves in composite materials can provide information about the interior of the structure,such as brittle cracks,delamination and bubbles.By analyzing the reflection,refraction,and interference of ultrasonic signals,inspectors can determine the location,shape,and size of the damage in order to assess its severity and potential impact. Infrared thermal imager can detect the difference of heat distribution in composite structures by detecting infrared radiation.Because the damaged area usually has different thermal conductivity and heat capacity,its radiant heat will be different from the surrounding area. With an infrared thermal imager,the inspector can observe changes in temperature on the image to determine the possible location and extent of damage.Optical fiber spectroscopy is a kind of damage detection technology based on the principle of optical fiber sensor.By embedding fiber in the composite structure and monitoring the change of fiber optical signal,the strain,temperature,pressure and other information of the structure can be obtained in real time.When the composite structure is damaged,the fiber will undergo deformation or stress change,which will affect the transmitted optical signal.By analyzing the changes in the optical signal,the location and extent of the damage can be determined.The advantage of these NDT technologies is that they can detect internal and hidden damage of composite structures in real time and accurately,without destroying the structure for testing.They provide a more comprehensive and detailed assessment of damage,which can help maintenance personnel develop accurate maintenance strategies and measures to safeguard structural integrity and safety.However,the application of NDT technology still faces some challenges,such as complex data analysis and interpretation,specialized requirements of equipment and completion

2.3 Structural monitoring system

Structural monitoring system is an advanced aircraft composite structural damage detection method,which uses various sensors and data acquisition equipment to monitor the health of aircraft structures in real time.The system can monitor the stress,strain,temperature and vibration of the composite structure from multiple angles,so as to realize early identification and prevention of damage and fatigue.The structure monitoring system uses high-precision sensors to collect various data of the composite structure,and then evaluates the performance and health status of the structure in real time through data analysis and algorithm processing.For example,the pressure sensor can measure the pressure distribution on the structure surface,the strain sensor can detect the extension and deformation of the structure,the temperature sensor can monitor the heat change of the structure,and the vibration sensor can record the vibration frequency and vibration amplitude of the structure.Through the structural monitoring system,maintenance personnel can remotely monitor the aircraft structure from the ground and obtain real-time status and performance data of the structure,including damage,fatigue and other anomalies.This data can be used to predict

the lifespan and maintenance needs of the structure to optimize maintenance plans and strategies.In addition,structural monitoring systems provide data history and trend analysis to help airlines and manufacturers assess the reliability and safety of structures and further improve design and manufacturing processes.In short,the application of structural monitoring system is very important to improve the safety and reliability of aircraft composite structures.It can monitor the health of the structure in real time,detect and diagnose damage in advance,and reduce repair work and downtime.At the same time,through the collection and analysis of data,the weaknesses and improvement space of the structure can be identified,which provides valuable experience and basis for future structural design and manufacturing.Despite the many advantages of structural monitoring systems,their application still faces some challenges,such as the stability and accuracy of sensors,the processing and management of large amounts of data,and the reliability and reliability of the system

Conclusion:

The damage detection and maintenance of aircraft composite structures is an important link to ensure aviation safety.In this paper,the classification,causes and detection methods of structural damage of aircraft composite materials are discussed,and the application of visual inspection,touch inspection and non-destructive testing techniques are introduced in detail.At the same time,we also discuss the maintenance methods and technologies of aircraft composite structures to ensure that the damage is repaired in time and to ensure the integrity of the structure.Through continuous research and technological innovation,we are confident to overcome these challenges and continue to promote the development of the field of inspection and maintenance of aircraft composite structures to ensure the safe flight of aircraft.

References:

[1]Zhang Guanbiao,Zhang Limeng,Liu Xiucai.Research on Structural Damage Threat Assessment of Composite Aileron of Civil Aircraft[J].Science and Technology Vision,2021(03):13-15.

[2]Kong Lei,Xing Ruishan.Discussion on Structural damage and detection and maintenance methods of Aircraft Composite Materials[J].China Equipment Engineering,2021(16):155-156.