Application of industrial CT to nondestructive testing of composite materials

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Abstract. Since China entered the process of reform and opening-up in the twentieth century, China's economic and technological levels have been developed rapidly, showing a flourishing scene on the whole, which has a great contribution to the development of China's industry and new technology research. Industrial computed tomography (ICT) technology, as a main means of visual inspection of industrial construction or other materials, has become more and more widely used in defect detection of resin-based conformance materials. It can effectively detect the content of impurities in the products, the location of pores, and so on, so as to accurately study the size and location of defects. Upgrading of the entire composite material.

Keywords: Industrial CT Technology; Resin composites; nondestructive testing; defects; Tomography.

1. Introduction
As an effective non-destructive testing method, industrial CT technology can be used to detect products ranging from millimeter micro-components to large space launch vehicles tens of meters high. It plays a key role in defect detection of composites. However, for industrial CT technology, the identification and measurement of small defects is also a difficult problem in the actual operation process. Therefore, this text starts with the connotation of industrial CT technology and composite materials, develops the corresponding software with the help of computer, establishes the model of tomographic images, eliminates the technical difficulties, and has guiding significance for improving the production process. An industrial CT system should include the following components: radiation source, radiation detector and collimator, data acquisition system, sample scanning mechanical system, computer system and auxiliary system (such as auxiliary power supply and radiation safety system). Industrial computed tomography (ICT) is traditionally used in automotive, material, aerospace, military, national defense and other industries. It has an important function that other non-destructive testing methods do not have in order to detect the quality of Aerospace Launch Vehicles and spacecraft engines, large-scale weapons, address structures, and mechanical products. This paper mainly studies its application in the field of composite materials.
2. The connotation of industrial CT technology and composites

2.1. Industrial CT Technology

Industrial computed tomography (ICT) is a kind of technology to build a three-dimensional model of the scanned object by means of computed tomography (CT). This technology has the characteristics of intuitive and accurate imaging fundamentally. In practical operation, it is mainly applied to nondestructive testing of industrial components. The earliest application of this technology was in the mid-late 1970s, initially used only in medicine, but in order to avoid damage to the human body, the adopted radiation source energy is low, penetration capacity is also limited. Later, it was used in the war process, mainly dealing with the detection process of aircraft turbine blades and rocket engines. At this stage, with the continuous progress of science and technology, industrial CT technology has been significantly developed, and has been widely used in all aspects of social development, such as aerospace, oil exploitation, electronic equipment, ceramics and composite materials[1].

2.2. Typical application

2.2.1. Pore defect detection. The internal structure of the object detected by industrial CT is non-contact and flying damage. The digital image without overlap is obtained, and the radiation density data of details are given, which makes it widely used in the initial detection of items. Because of the complexity of composite materials, the general nondestructive testing can not directly and efficiently detect the porous defects of key components of materials. CT stereo scanning can clearly show the three-dimensional status of the structure, showing the existence of voids and gaps that may affect the integrity and firmness of the structure.

2.2.2. Fatigue crack detection. According to statistics, 80% of material damage is fatigue damage, especially with the development of large-scale, complex structure, high temperature and high speed, the research on fatigue life has become the focus of attention. The detection of crack behavior is very important for accurate prediction of material fatigue life.

2.2.3. Reverse engineering. Traditional product production process is from design drawings to processing and assembly into finished products. Reverse engineering hi scans a series of products with unknown structure by means of industrial non-destructive testing equipment CT. At present, there are roughly three ways in the research direction of reverse engineering application both at home and abroad: (1) industrial CT tomography and automatic forming machine are used to produce products. This method is most convenient for the construction of complex and distorted spatial shapes, but it can only be applied to components of one kind of material; (2) The three-dimensional images obtained by the first way are distinguished by professional software to obtain the characteristic dimensions of the structure, such as length, width, height and diameter, which are in line with the traditional processing technology to obtain products. This method is only suitable for the construction of materials with fewer types; (3) multi-directional tomography of unknown products. Scanning image is obtained, the characteristic size of each part of the product is accurately measured, the unknown size and density changes are drawn, and then processed with modern processing technology.

2.3. Composites

Composite is a kind of fiber reinforced material based on organic polymer. Its components are epoxy resin and unsaturated polyester resin, mainly thermoplastic resin. This thermoplastic resin can dissolve in organic solvents or reach its melting point in an overheated environment. When heated, the final viscous liquid is formed due to the softening and melting process. In order to make the desired shape, the resin-based composite is formed after cooling and solidification. Material Science. This composite material has also been widely used in more aspects of social development, especially in the chlor-alkali industry, paper industry, metal surface treatment industry and so on, with significant practical
significance. According to the different composites of basic materials, composite materials can be divided into three categories: resin matrix composites, metal matrix composites and ceramic matrix composites. It is possible to go through different technological stages at any stage before the finished products are manufactured. Porosity is an important index for quality inspection of composite materials.

3. Experimental study of industrial CT in defect detection of composites

3.1. Equipment preparation and laboratory environment construction
In order to ensure the validity and accuracy of the experiment, the equipment used in this experiment is the industrial CT system produced by the German Icoshoran International Radiation Company Limited. This kind of CT system has two obvious advantages, one is the linear scan detector, the other is the area scan detector. The spatial resolution of these two detectors is very high, and can reach 4.0lp/mm, which can guarantee the detection accuracy of the construction [2]

3.2. Selection of samples
Mainly select composite products made of high silica and carbon fiber materials.

3.3. Selection of technical means
Acoustic Emission (AE) is the first technique that can be used to evaluate the properties of composites by detecting and analyzing the emission signals produced during the loading process of compositions and structures of composites. The quantity level, as well as some defects, can effectively improve the efficiency of the experiment in the actual application process. The second is to use the Radiographic Testing (RT) technology, which uses the characteristics of absorption and scattering of rays (X-ray, gamma-ray, neutron ray, etc.) through the object, to detect the discontinuity of its internal structure. The application of this technology mainly aims at the defect of resin aggregation and fiber aggregation, which can detect the defect of material in detail from the angle of layering and grading. The advantages of this technique are obvious, and it is not limited by the geometric structure of the specimen when the penetration energy is enough.

4. Application of industrial CT in defect detection of composites
Firstly, the experimental results should be analyzed. After accurate data analysis, the image features of different defects can be combined to judge, so as to facilitate the elimination and improvement of defects. The most obvious picture quality is the CT image of stomatal defects. As an important factor that leads to the unqualified quality of composites, pore is put into use directly after the original material has not undergone a certain aging preheating process, and ultimately makes the content of water in raw materials become larger. In the later melting and curing process, not only water vapor will not be discharged, but also will be released. Because of gas entry, more stomatal defects appear. This can be clearly seen in the image, generally speaking, the image of stomatal defects will show more circular or elliptical, dark black areas, the outline of the entire stomatal is smooth, there are obvious boundaries between each other, which can provide accurate data for the analyst. The other is lamination defect detection, which means that the material may be seriously damaged. The reason for this phenomenon is due to the resin flow and fiber slippage in the discontinuous area of the fiber, which needs attention.

The industrial CT technology can be used to detect and analyze the composite products, and the reasonable use of industrial CT technology can be found. It can be used to detect the impurities, pores and other defects in composite materials with high accuracy and sensitivity, so as to effectively optimize the process technology of composite products, from a certain point of view. To a certain extent, it can greatly promote the quality of composites and greatly improve the work efficiency.

5. Concluding remarks
In summary, with the development of science and technology, the development of industrial CT technology is also gradually progressing. Therefore, it is very important to detect the defects of
composite products by means of industrial CT technology. And in a long time of practical experience, a large number of results show that industrial CT technology for composite products can make accurate detection of the location of pores, delamination defects, impurity components, etc., but also effective geometric size of defects.

The excellent performance of industrial CT makes its detection, manufacturing and scientific research. The field has a broad application space. Although industrial CT has some shortcomings, I believe that with the development of technology and the in-depth application of industrial CT, industrial CT equipment.

The technical performance will be further developed and improved. At the same time, with the development of remanufacturing in our country, industrial CT, as an advanced detection tool, can visually detect the workpiece under test, and has a high detection sensitivity and resolution for the internal defects and structural characteristics of the workpiece, which can provide a more intuitive detection and analysis for the damage mechanism of remanufactured parts. It has important scientific significance for predicting the service life of remanufactured parts, mastering their failure rules and ensuring the service safety of remanufactured products.

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