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Neutron Tomography Application for Aircraft-parts and Root of Ginseng

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1. Introduction

The neutron computerized tomography is considered to be a complementary tool to X-ray tomography in the sense that neutron interacts with atomic nucleus, otherwise X-ray interacts with an orbital electron of atom. The neutron tomography compared with X-ray tomography has a relatively short history. It is employed in stationary, as neutron sources are produced by the nuclear reactor. The full potential of the neutron tomography has yet to be investigated.

Since, HANARO NRF was installed in 1995 [1], the neutron radiography research group of KAERI has been developed the non-destructive testing methods by the computer tomography served for 1) aerospace industry and 2) agricultural industry.

Concerning to NDT for aerospace, research was cooperated with Korean Air force. At the first stage, research was focused to find the micro-cracks based on internal passages inside aircraft parts and residual core of turbine blade [2]. Concerning to NDT for agriculture, research was cooperated with the Agricultural Development and Technology Center. Research was focused to find the alive roots of Korean ginseng [3].

2. Experimental Methods

Neutron tomography devices were installed at the research reactor HANARO of the KAERI. The incident quasi-parallel neutron beam from the HANARO reactor interacts with a sample placed on a rotation table. The detection system records the distribution of the transmitted beam attenuated by the sample. Step motors permit the specimen to be translated into the two transverse directions and rotated. The rotation table is placed on rails and can be moved along the beam axis manually

2.1 Experimental Devices and Conditions

The detection system is mainly consisted of a scintillation converter of NE-426 (^{6}LiF/ZnS:Ag), a CCD camera, and a computer software for image processing [4]. In where, NE-426 (^{6}LiF/ZnS:Ag) has a function that it absorbed a neutron and emits a photon.

NE-426 At 30MW power of HANARO, exposure time of 40 second is required to capture one projection image to beam flux of 6.00×10^6 n/(cm^2-sec). Therefore, in order to capture a typical set for one sample, the exposure time of 3 hours is normally used.

2.2 Exprimental Procedure for Micro-cracks and Residual cores of Aircraft-parts

Non-destructive testing for micro-crack based on internal passages in aircraft parts is required in complex. Tagging process technique used by thermal neutron beam is one of preferable method to detect a micro-crack. We has developed and performed the tagging process technique at the HANARO research reactor. Tagging process is commonly used for detection of residual core material in gas-cooled turbine blades [5]. A 0.3 Molar solution of gadolinium nitrate hexahydrate dissolved in mixture of 1:1 of methyl alcohol and distilled water is used to detect the defection of internal passages in turbine blades. To trace the micro-cracks of aircraft-parts or others, similar tagging technique can be applied. Otherwise, low content of gadolinium nitrate solution may not be used, because X-ray film density to low content gadolinium-image in less than 200 μm gap size can be diminished with image of other elements. In addition, we made the gap of micro-crack be evacuated to fulfill a gadolinium solution.

The process of tagging a gadolinium solution to micro-crack is following steps; (1) Rinsing the surface of sample - sample is immersed for a while in alcohol and showed by water for surface cleaning. (2) Drying sample - after rinsing the samples, they should be dried in hot air. (3) Fulfill gadolinium solution in micro-crack - gadolinium solution is fulfilled by vacuum at very low pressure. Our vacuum was operated by about 0.2 atm. (4) Rinsing gadolinium solution on surface - gadolinium solution on surface of sample should be rinsed for thermal neutron exposure. (5) Drying sample - the surface of sample should be dried in fully enough. (6) Exposing sample to neutron - sample is tested by thermal neutron exposure.

Figure 1 shows the flow chart of tagging process.

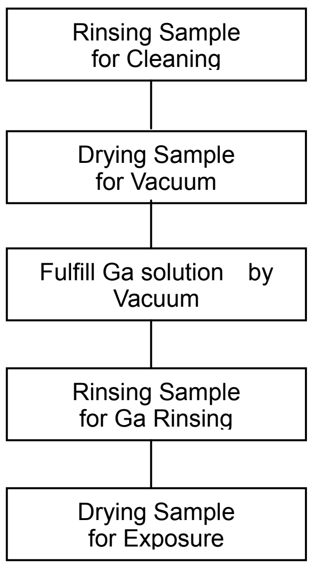

Figure. 1. Tagging Procedure

2.2 Experiment for Alive Roots of Ginseng

The goal of this experiment is to observe a growing process of roots of ginseng in soil. Alive ginseng was packed in cylindrical aluminum capsule. As the water has very high neutron absorption coefficient, we dried the soil for a while before exposure.

3. Results

We can see the micro-crack by both analyzed methods: X-ray film and three-dimensional tomography. In figure 2 (a), dark spots show the tagging of gadolinium solution. Figure 2 (b) shows the micro-crack of the turbine blade.

(a)

(b)

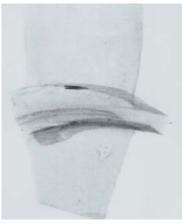

Figure 2 (a) Traces of gadolium tagging inside parts of air-craft (b) Trace of micro-crack on surface of turbine blade. All figures were captured by neutron tomography

To observe the roots in soil, we finally got remarkable result. Figure 3 (a) shows a cross section view of the roots of ginseng and figure 3 (b) shows the roots of ginseng observed by three dimensions

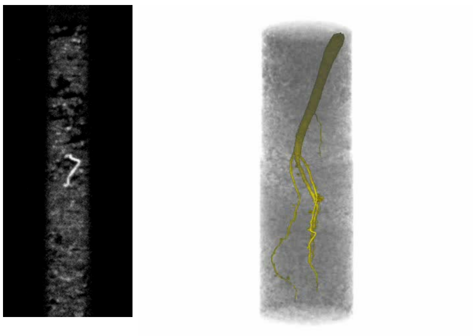

Figure 2 (a) Roots of ginseng in soil in two dimensions where white color shows a root. (b) Root of ginseng in three dimensions All figures were captured by neutron tomography

4. Conclusion

Tomography using a thermal neutron beam from HANARO makes good approach for obtaining good contrast images. Initial tests with several samples have been performed to acquire the basic data for further improvements of the facility. Through this experiments of NDT for aircraft-parts and roots of ginseng, we finally got the remarkable results. In addition, we proved that HANARO NRF has so many potentials in research area of aerospace industry and agricultural industry for future

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