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Detecting Air Holes in a Concrete Structure Using Gamma-Ray Tomography Technique

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ABSTRACT: Tomography is a technique in order to display a representation of a cross-section through solid objects using x-rays, gamma rays or ultrasound waves. The purpose of this paper is to provide a non-invasive technique for creating a CT image and detecting air holes in a concrete structure using gamma-ray tomography technique. In this work, the concrete column with a cross-section of 40 cm × 40 cm and a length of 3 meters was considered as the desired structure. There were two air holes in the concrete column. Also, the isotope Cs-137 was considered as a radioactive source. One NaI(Tl) scintillation detector was used in order to measure the rate of gamma-rays emitted by the radioactive source. This structure was simulated using the MCNPX code. Then, the image of the cross-section was reconstructed using the obtained data of MCNPX, MATLAB software, and the ART algorithm. In the ART method, it was assumed that the cross-section contains unknown pixels. A row matrix (1 × n) and a column matrix (n × 1), which are the sum of the row pixels and column pixels of the image were defined as input for ART algorithm. The output was a matrix (n × n) that matrix arrays (n × n) are cross-section image pixels. Therefore, using these arrays, the cross-sectional image was reconstructed. The reconstructed image showed the correct location of the air holes. According to the obtained results, the proposed gamma radiation tomography technique was an appropriate and non-invasive technique in order to a cross-sectional analysis of concrete structures.

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1. INTRODUCTION

Recently, tomography is used in many different applications such as Multiphase measurement which is encountered in many modern industrial and environmental processes, medical imaging, mechanical and structural measurement, chemical and petrochemical gauging, oil and gas gauging and etc. The multiphase flow systems, vastly used in industrial production of polymers, minerals, pharmaceuticals, food and feed are the major targets of computed tomography (CT) [1].

2. METHODOLOGY

In this work, the concrete column with a cross-section of 40 cm × 40 cm was considered as desired structure. The length of the column was 3 m. There were two air holes in the concrete column. Also, the isotope Cs-137 which has a half-life 30 years, was regarded as a radioactive source. Cs-137 emits gamma-rays with 662 keV. One NaI(Tl) scintillation detector was used to measure the rate of gamma-rays emitted by the radioactive source. This structure was simulated using the MCNPX code. A schematic of the simulated concrete column and gauging structure using MCNPX code is illustrated in Figure 1.

MCNPX code was used for neutron, photon, electron, or coupled neutron-photon-electron transport [2]. Calculations were done per source particle using Pulse Height Tally F8 in MCNPX Monte Carlo computer code. Statistical uncertainty associated with the Monte Carlo transport simulation results presented in this paper, with 10 million histories run, is less than 0.5%. Then, the gamma-ray source was placed on one side of the column and a detector was diametrically located on the other side. The whole of the concrete column was swept by source and detector (pencil beam). Path of the radioactive

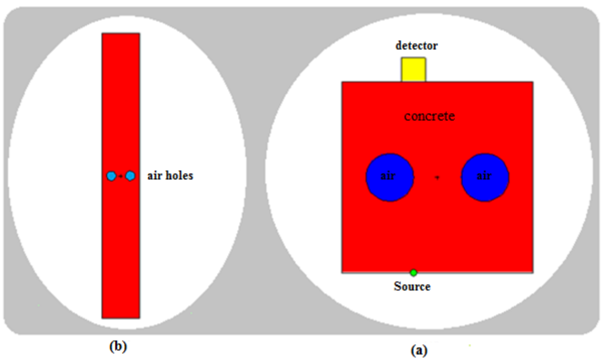

Fig. 1. The schematic view of simulated setup configuration in the MCNPX code.

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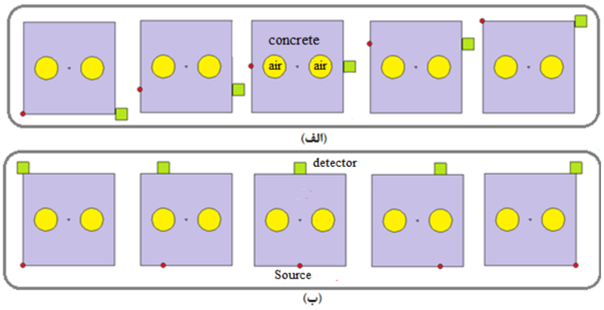

Fig. 2. Path of the radioactive source and the detector along the two sides of the column.

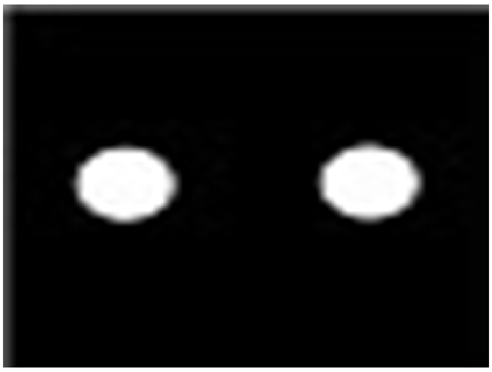

Fig. 3. The used image in order to test the written ART algorithm

source and the detector along the two sides of the column is shown in Figure 2. The required data was obtained in order to reconstruct the cross-sectional image. After that, the image of the cross-section was reconstructed using the obtained data of MCNPX, MATLAB software, and the ART algorithm. In this study, the ART which is an algebraic technique was used. In the ART method, it was assumed that the cross-section contains unknown pixels. So, the image reconstruction problem can be considered as a system of linear equations. A row matrix (1 × n) and a column matrix (n × 1), which are the sum of the row pixels and column pixels of the image were defined as input for ART algorithm. The output was a matrix (n × n) that matrix arrays (n × n) are cross-section image pixels [3]. Therefore, using these arrays, the cross-sectional image was reconstructed.

Table 1 shows the obtained results for the proposed gamma tomography.

3. RESULTS AND DISCUSSION

ART algorithm was developed using MATLAB software in order to reconstruct the internal image using obtained data from the MCNPX code. Firstly, the required data for testing of the ART algorithm were obtained from the well-known image (Figure 3). The validation of written ART algorithm was done and the obtained image by this algorithm showed the efficiency of the code (Figure 4).

The next step in this investigation was the reconstruction of a cross-sectional image of a typical concrete column. For this purpose, the data obtained from the MCNPX code was defined as the input of the ART algorithm. The reconstructed image showed the correct location of the air holes. The final reconstructed image as a result of MCNPX code data and the ART algorithm is shown in Figure 5.

According to the obtained results, the proposed gamma radiation tomography technique is an appropriate and non-invasive technique in order to the cross-sectional analysis of concrete structures.

Table 1. Obtained results for the gamma tomography.

Moving along X-axis			
Radiation along Y-axis			
Counted photons	points	Counted photons	points
2.57E-04	22	4.26E-01	1
2.57E-04	23	2.63E-04	2
2.57E-04	24	2.57E-04	3
2.57E-04	25	2.57E-04	4
3.50E-04	26	2.57E-04	5
7.64E-04	27	3.50E-04	6
1.12E-03	28	6.94E-04	7
1.39E-03	29	1.12E-03	8
1.56E-03	30	1.39E-03	9
1.62E-03	31	1.56E-03	10
1.56E-03	32	1.62E-03	11
1.39E-03	33	1.56E-03	12
1.12E-03	34	1.39E-03	13
7.65E-04	35	1.12E-03	14
3.42E-04	36	7.65E-04	15
2.57E-04	37	3.42E-04	16
2.57E-04	38	2.57E-04	17
2.57E-04	39	2.57E-04	18
2.62E-04	40	2.57E-04	19
4.26E-01	41	2.57E-04	20
		2.57E-04	21
Moving along Y-axis			
Radiation along X-axis			
Counted photons	points	Counted photons	points
9.64E-03	22	4.26E-01	1
7.61E-03	23	2.63E-04	2
4.94E-03	24	2.58E-04	3
2.34E-03	25	2.58E-04	4
5.48E-04	26	2.58E-04	5
2.58E-04	27	2.58E-04	6
2.58E-04	28	2.58E-04	7
2.58E-04	29	2.58E-04	8
2.58E-04	30	2.58E-04	9
2.58E-04	31	2.58E-04	10
2.58E-04	32	2.58E-04	11
2.58E-04	33	2.58E-04	12
2.58E-04	34	2.58E-04	13
2.58E-04	35	2.58E-04	14
2.58E-04	36	2.58E-04	15
2.58E-04	37	5.62E-04	16
2.58E-04	38	2.34E-03	17
2.58E-04	39	4.94E-03	18
2.64E-04	40	7.61E-03	19
4.26E-01	41	9.64E-03	20
		1.04E-02	21

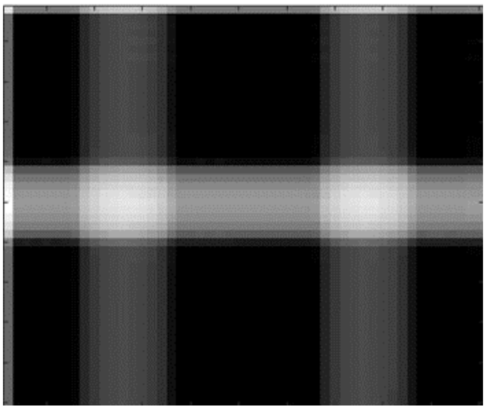

Fig. 4. The reconstructed image from a well-known image which is illustrated in Fig 3 by the ART algorithm.

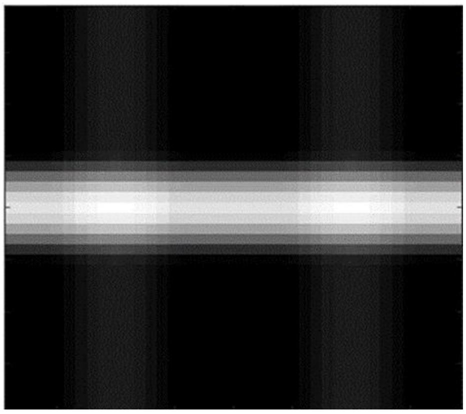

Fig. 5. The final reconstructed image as a result of MCNPX code data and the ART algorithm.

4. CONCLUSIONS

The presence of air bubbles inside the concrete caused instability and reduced the strength of the concrete. Therefore, the technique of gamma radiation tomography, which is able to analyze the internal structure of concrete non-invasively in order to identify the bubbles in it, was a useful and efficient tool for determining the quality of concrete structures. In this paper, a technique for creating a CT image and detecting air holes in a concrete structure was presented.

REFERENCES

[1] "Industrial Process Gamma Tomography", Final report of a coordinated research project 2003-2007, International Atomic Energy Agency, May 2008.
[2] MCNPXTM USER'S MANUAL, Version 2.5.0, 2005.
[3] Oliveira, E. F. Melo, S. B. Dantas, C. C. D. Vasconcelos, A. A. Cadiz, L. F. " comparison among tomographic reconstruction algorithms with a limited data", International Nuclear Atlantic Conference, (2011).

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