The Radionuclide Distributions within Simulated Samples by Emission Tomographic Gamma Scanning

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1. Introduction

Tomographic Gamma Scanning method is one of Non-Destructive Assay (NDA) methods used for determining radioactive contents within irradiated materials, for example, fuel rod in hot cell at Irradiated Materials Examination Facility (IMEF) of Korea Atomic Energy Research Institute (KAERI).

For the purpose of determining the radio-nuclide distributions within simulated samples quantitatively. We attempt to investigate the feasibility of newly developed Emission Tomographic Gamma Scanning technique[1].

In this paper, we first set up emission TGS equations and discuss the algebraic reconstruction technique (ART) for emission image in simulated samples.

Secondly, the simulation results are obtained for simulation model, based on the developed software in the absence of real experimental data.

Finally, in order to verify the simulation results, several computational schemes are conducted, the results which absolute relative errors are less than 10% show that we have simulated and implemented the determination of simulated samples by TGS technique successfully[2].

2. Emission TGS equation and Algebraic Reconstruction Technique

The reconstructed cross section of the measured object is divided into picture elements, voxels. The fraction of the emitted quanta from a certain voxel reaching the detector in a certain position can be calculated theoretically. Summation over all voxels, gives the gamma-ray intensity in the detector in a certain position. The basic expression for the emission TGS may be written as follows[3]:

$$W \cdot A = I \quad (1) \quad \text{or} \quad \sum_{j=1}^{J} W_{ij} \cdot A_j = I_i \quad (2)$$

here $i = 1, 2, \cdots, N_d$, $j = 1, 2, \cdots, N_v$

W_{ij} : contribution coefficient from voxel j to the detector in position i

A_j : gamma-source intensity voxel j (sought activity in voxel j)

I_i : measurement (the count rate) in measurement position i

Using measured data (count rates) in a large number of detector positions, an equation system is obtained:

$$\begin{bmatrix} W_{11} & W_{12} & W_{13} & \Lambda & W_{1N_v} \\ W_{21} & W_{22} & W_{23} & \Lambda & W_{2N_v} \\ W_{31} & W_{32} & W_{33} & \Lambda & W_{3N_v} \\ \mathrm{M} & \mathrm{M} & \mathrm{M} & \Lambda & \mathrm{M} \\ W_{N_d1} & W_{N_d2} & W_{N_d3} & \Lambda & W_{N_dN_v} \end{bmatrix} \bullet \begin{bmatrix} A_1 \\ A_2 \\ \mathrm{M} \\ A_{N_v} \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \\ \mathrm{M} \\ I_{N_d} \end{bmatrix} \quad (3)$$

3. Simulation

The simulation procedures can be divided into four parts : (1) calculation of the contribution efficient matrix W: (2) simulation of measurements I for pre-set A: (3) reconstruct the intensities A by ART

algorithm: (4) verify the tomographic reconstruction algorithm ART.

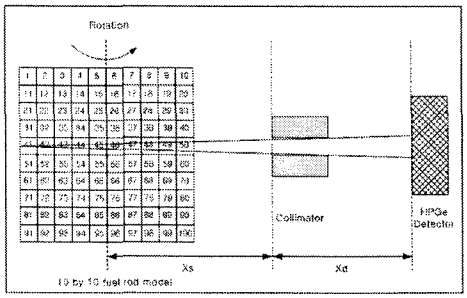

Fig. 1. Schematic of the simulated equipment.

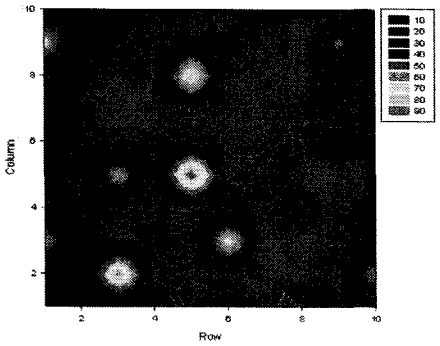

Fig. 2. Gray intensity of reconstructed image from 10 by 10 simulated samples

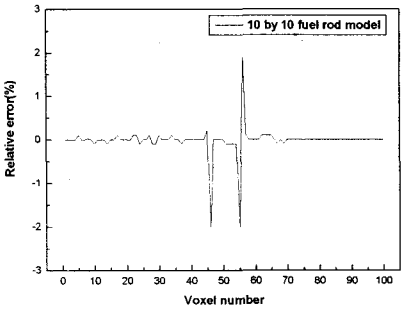

Fig. 3. The relative error of the intensity distribution between "reference" value and "reconstructed" value in each voxel(10 by 10).

4. Conclusion

The emission TGS method for determining the radio-nuclide distributions within simulated samples has been investigated. Tomographic simulations and reconstructions have been performed by mathematical method and ART algorithm respectively. The simulation results show that TGS technique is suitable for determining radio-nuclide distribution in simulated sample. TGS has been used in radioactive waste characterization as well, the research of radioactive waste assay by TGS is under study.

REFERENCES

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