Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-18, 2012

The Influence of Void on Image Quality in Industrial SPECT: a Monte Carlo Study

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1. Introduction

Recently, industrial SPECT was developed in the Korea Atomic Energy Research Institute (KAERI) to investigate the spatial distribution, mixing characteristics, and flow pattern of flow media in industrial process plants [1]. To improve the image quality, various technique were proposed by Park et al., and the performance of industrial SPECT was evaluated by the Monte Carlo code and experiments under single phase flow case in the vessel [2, 3].

In practice, industrial flows are mixture of different phases with various specific purposes such as mass transfer, purification and etc [4]. In the present study, industrial SPECT and homogeneous void were simulated by using Monte Carlo code in order to evaluate the effect of void in the vessel on image quality of industrial SPECT.

2. Methods and Results

Industrial SPECT was modeled with the MCNPX code. 36 NaI(Tl) cylindrical scintillation detectors (1.3 cm diameter and 2.5 cm height) were placed around a 40 cm diameter cylindrical vessel (filled with water) in a hexagonal configuration (figure 1-(a)), and point sources of ^{68}Ga (511 keV) and ^{137}Cs (662 keV) were located at the center of the vessel. The energy window was set to 460~562 keV for ^{68}Ga and 596~728 keV for ^{137}Cs.

Figure 1-(b) shows the homogeneous void formation at the same layer with the 6 detectors of industrial SPECT. The position of void was determined randomly by using MATLAB program. The radius of void was fixed as 0.7 cm, and the void volume fraction was varied to 5, 10, and 20%. The density of void filled with air was 0.001205 g/cm^3.

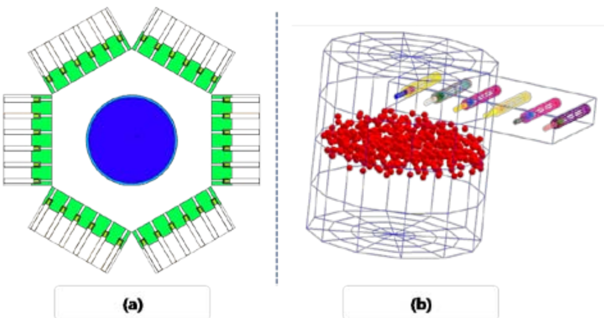

Fig. 1. (a) Geometry of Industrial SPECT, and (b) homogeneous void formation in the vessel with 6 NaI(Tl) detectors of industrial SPECT.

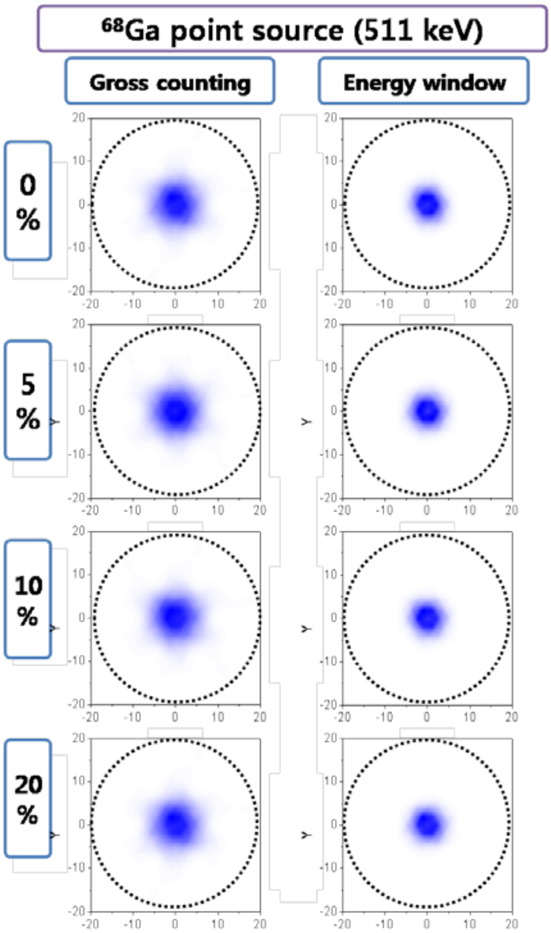

Fig. 2. Reconstruction images of ^{68}Ga point source for the counting method and the void volume fraction.

The normalized root mean square error (NRMSE) was calculated to evaluate quantitatively the influence of the void on image quality. The NRMSE was used to compare the reconstruction image in the void condition with the reconstruction image in the normal condition.

Figure 2 and 3 show, for the ^{68}Ga and ^{137}Cs sources, respectively, reconstruction images in the normal condition and in the different void fraction condition. In figure 2 and 3, for both of these sources, the void formation in the vessel did not make significant influence on the quality of the reconstructed images.

Table I shows a quantitative estimation of the image quality for the void formation condition. The NRMSE value was increased with decreasing the source energy and increasing the void volume fraction, and the NRMSE values of industrial SPECT without employing the energy window were higher than those cases with

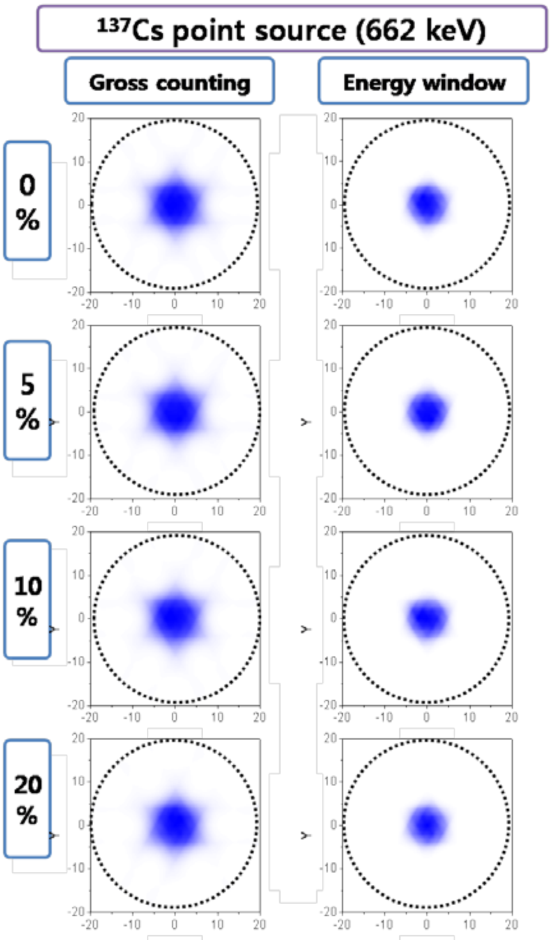

Fig. 3. Reconstruction images of ^{137}Cs point source for the counting method and the void volume fraction.

the energy window. The NRMSE values were only within 4%, and it means the void in the vessel hardly influence on the image quality in industrial SPECT.

Table I: NRMSE for quantitative comparison of reconstruction image quality

Source	Counting Method	Void volume fraction		
		5%	10%	20%
^{68}Ga (511 keV)	Gross	1.928%	2.333%	3.668%
	Peak	1.693%	2.017%	2.596%
^{137}Cs (662 keV)	Gross	1.876%	2.187%	3.588%
	Peak	1.423%	1.998%	2.522%

3. Conclusions

The influence of void on image quality in industrial SPECT was evaluated to by using the MCNPX code. The results show that the void formation in the vessel hardly affects on the image quality in industrial SPECT. There are two reasons in the results; (1) the homogeneous void distribution in the vessel uniformly influences on signals of every detector, and (2) there are few gamma interactions in the void because the density of the void is as low as 0.001205 g/cm^3. This result will be verified with following experiments.

Acknowledgement

This work was supported by the Nuclear Research and Development Program of the Korean Ministry of Education, Science, and Technology.

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