Effect of the Number of Detectors on Image Quality in Industrial SPECT

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1. Introduction

In industrial process plants, radioisotopes have been widely used to examine the spatial distribution, mixing characteristics, and flow pattern of process media [1]. However, it is still a great challenge to acquire a reliable result for imaging a multiphase flow in a refinery and petrochemical plant on a real-time.

Legoupil et al. proposed an industrial single photon emission computed tomography (SPECT) to image the flow distributions of a process system. The SPECT system has the advantage of a real-time estimation and analysis of flow distribution [2, 3].

In this study, to evaluate the effect of the number of detectors on image quality in industrial SPECT, several different geometries were simulated by the Monte Carlo method [4].

2. Methods and Results

In this study, detector arrays and the point source of ^{99m}Tc and ^{68}Ga located in the cylindrical vessel object (30 cm diameter, filled with water) were modeled using the MCNPX code. Fig. 1 shows the geometry of collimator and detector mounted in detector arrays. The geometry of collimator (R_g was 4 cm at the center of the vessel, 28 cm from the collimator) was designed by the equation of geometric resolution of collimator (denoted by R_g) and CsI(Tl) (1.2 × 1.2 × 2 cm^3) detectors were used [5].

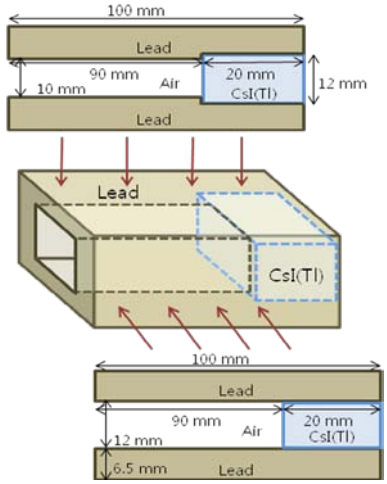

Fig. 1. Geometry of collimator and CsI(Tl) detector

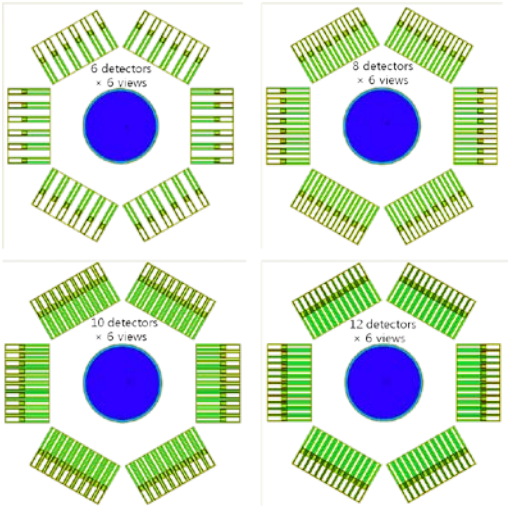

Fig. 2. Geometries of Industrial SPECT of 6 detectors × 6 views, 8 detectors × 6 views, 10 detectors × 6 views and 12 detectors × 6 views modeled in the MCNPX code

To determine the optimal number of detectors of the industrial SPECT, the geometry of 6 detectors × 6 views (total 36 detectors), 8 detectors × 6 views (total 48 detectors), 10 detectors × 6 views (total 60 detectors), and 12 detectors × 6 views (total 72 detectors) were taken into account (Fig. 2), and the SPECT images of each geometry were reconstructed by using the expectation maximization (EM) algorithm. To reduce computation time required for system matrix of the EM algorithm, the reciprocity theorem was applied [6]. The reciprocity theorem is that exchanging the position of a source and a detector does not change the amount of radiation counted by the detector when the primary ray is only considered. To apply reciprocity theorem, the energy windows used in this study were 126 – 154 keV and 460 – 562 keV for ^{99m}Tc (140 keV) and ^{68}Ga (511 keV), respectively.

Fig. 3 shows the reconstructed images of industrial SPECT. The reconstructed images acquired for 12 detectors × 6 views shows significant improvement of the spatial resolution when compared with the reconstructed images of 6 detectors × 6 views. Especially, the reconstructed images for 12 detectors × 6 views precisely indicate the source region.

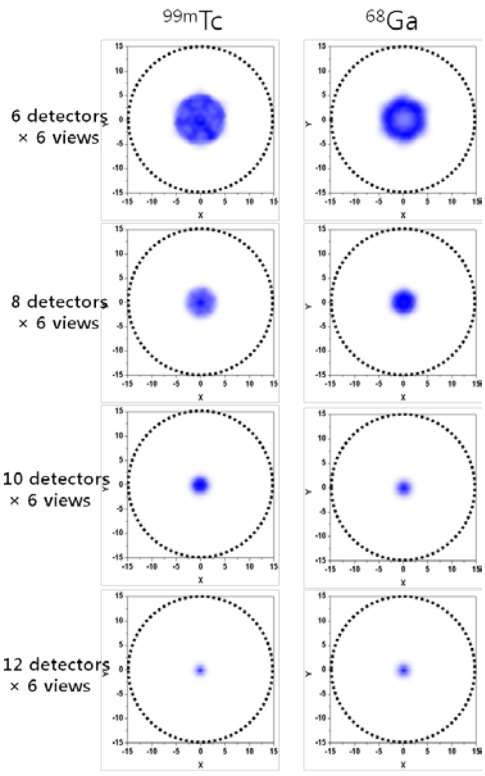

Fig. 3. Reconstructed images of ^{99m}Tc and ^{68}Ga point source for different geometries

The profiles of the reconstructed images for ^{99m}Tc and ^{68}Ga are shown in Fig. 4. For both of these sources, the profiles of 6 detectors × 6 views and 8 detectors × 6 views cannot locate the source position. However, the correct position of the source is indicated in the profiles of 10 detectors × 6views and 12 detectors × 6 views.

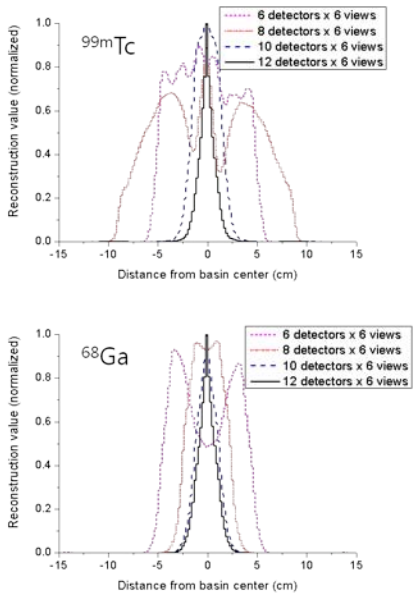

Fig. 4. Profiles of reconstructed images of a ^{99m}Tc and ^{68}Ga for different geometries

3. Conclusions

In the present study, the effect of the number of detectors on image quality was confirmed. The result shows that increasing the number of detectors in industrial SPECT significantly improved the quality of the reconstructed image. Especially, more than 60 EA detectors (10 detectors × 6 views) of industrial SPECT were suitable for the 30 cm diameter cylindrical vessel. This result will be considered to construct industrial SPECT for 30 cm diameter cylindrical vessel.

Acknowledgement

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