Feasibility Study of Multi-gamma Industrial SPECT for Multiphase Flow Measurement

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1. Introduction

A multiphase flow system, which transport, mix, and react two or more process flow, has been widely used and considered as an important part in various plants. Therefore, it is very helpful to monitor the process operating conditions in the system for the efficient operation, cost saving and product quality assurance [1].

Some researchers have suggested to apply a medical single photon emission computed tomography (SPECT) technique for industrial process diagnosis. But compared to the medical SPECT, an industrial SPECT system is designed for a large industrial object, therefore, the configuration of the industrial one has to be different to the medical one. Recently, researchers working for Korea Atomic Energy Research Institute (KAERI) has developed various types of industrial SPECT and evaluated its performance experimentally [2-4]. However, all the developed system could monitor only one process flow even though it is necessary to confirm two or more process flow simultaneously.

In this study, the industrial SPECT system with 36 channel multi-channel analyzer (MCA) was developed for multiphase flow measurement, and its performance was evaluated experimentally with ^{68}Ga and ^{137m}Ba sources.

2. Methods and Results

2.1 Structure of industrial SPECT system

The multi-gamma industrial SPECT system for 40 cm diameter acrylic water object is composed of 6 detector arrays arranged in a stationary hexagonal shape around an imaging object, and each detector array consists of 6 sets of lead collimated NaI(Tl) detectors (Fig. 1). For the data acquisition system, 36-port MCA was developed at KAERI to count gammas along with its energy.

For performance evaluation of the SPECT system, a flow system was constructed as shown in Fig. 2. The flow system is composed of the column, the ion exchanger, the radioisotope injection point, and the control panel. The control panel shows a flow rate automatically, and the injection point and ion exchanger are shielded by leads. Radioisotopes are injected at the point, go through the column, and then they are captured and shielded at the ion exchanger. Therefore, there will be no radioisotopes in the system after one circulation in flow system except the ion exchanger. 6.1 mCi of a ^{68}Ga radiotracer (511 keV) and 4 mCi of ^{137m}Ba were extracted from a ^{68}Ge-^{68}Ga generator and ^{137}Cs-^{137m}Ba generator respectively and instantaneously injected at the injection point. The flow rate was 4.87 L/min at that time. Gammas emitted from the sources are selectively recorded by MCA with energy every seconds.

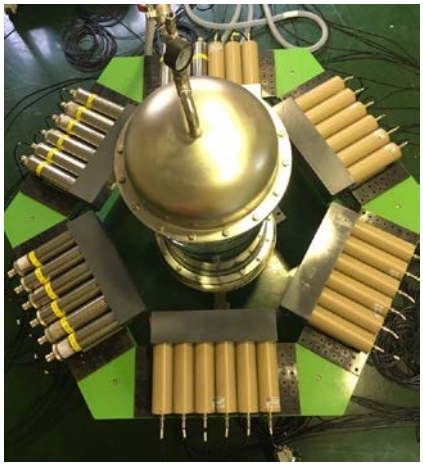

Fig. 1. Multi-gamma industrial SPECT system with 36 NaI(Tl) detectors.

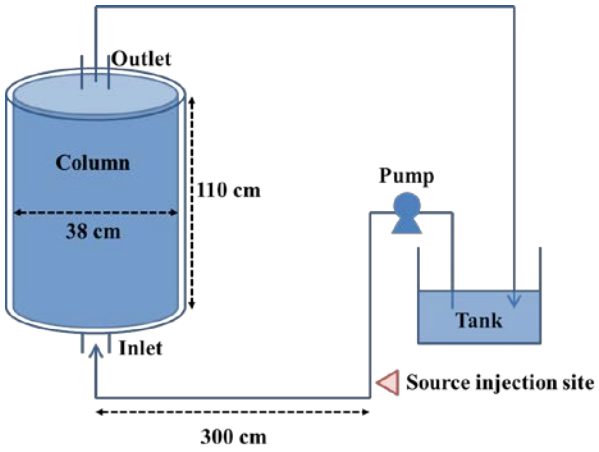

Fig. 2. Schematic of the flow system for the experiments.

2.2 Image Reconstruction

The appropriate use of image reconstruction algorithm is very important for acquiring high-resolution images. The maximum-likelihood expectation-maximization (ML-EM) algorithm was used for the image reconstruction process in this study. The system

matrix, which is necessary for reconstruction images, was calculated through a Monte Carlo n-particle 6 (MCNP6) code [5].

2.3 Performance evaluation

Fig. 3 shows the reconstructed images for the movement of ^{68}Ga and ^{137m}Ba sources. The patterns of images are very similar to each other, which means that the multi-gamma industrial SPECT system is suitable for monitoring two or more process flows. The sources appeared at the left side of the column, which is opposite to inlet, at 42 s after source injection, moved to the right of the column through bottom side, and then disappeared gradually.

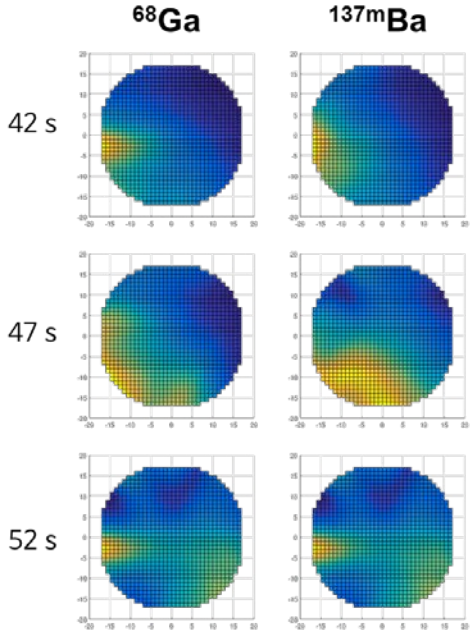

Fig. 3. Reconstructed images for the movement of ^{68}Ga and ^{137m}Ba sources. The sec means the time after source injection.

3. Conclusions

In this study, the multi-gamma industrial SPECT system was developed and its performance was evaluated experimentally with ^{68}Ga and ^{137m}Ba sources. It was found out that the system was appropriate for monitoring various flow instantaneously and additional experiment will be carried out with another column and flow system, which have two or more injet and source injection point.

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