Gamma Ray Tomographic Scan Method for Large Scale Industrial Plants

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1. Introduction

The gamma ray tomography systems have been used to investigate a chemical process for last decade [1,2]. There have been many cases of gamma ray tomography for laboratory scale work but not many cases for industrial scale work. Non-tomographic equipment with gamma-ray sources is often used in process diagnosis. Gamma radiography, gamma column scanning [3] and the radioisotope tracer technique [4] are examples of gamma ray application in industries. In spite of many outdoor non-gamma ray tomographic equipments, the most of gamma ray tomographic systems still remained as indoor equipments. But, as the gamma tomography has developed, the demand on gamma tomography for real scale plants also increased. To develop the industrial scale system, we introduced the gamma-ray tomographic system with fixed detectors and rotating source. The general system configuration is similar to 4th generation geometry. But the main effort has been made to actualize the instant installation of the system for real scale industrial plant.

This work would be a first attempt to apply the 4th generation industrial gamma tomographic scanning by experimental method. The individual 0.5-inch NaI detector was used for gamma ray detection by configuring circular shape around industrial plant. This tomographic scan method can reduce mechanical complexity and require a much smaller space than a conventional CT. Those properties make it easy to get measurement data for a real scale plant.

Fig. 1. RFCCU

2. Methods and Results

To evaluate this method, real scale experiments were conducted for a RFCC riser of 180 cm diameter in refinery. RFCCU (Regenerated Fluidized Catalytic Cracking Unit) is an industrial plant to convert heavy oil into gasoline by catalyst cracking. The RFCCU consist of riser, cyclone and regenerator. The most of reactions take place in riser in which the multi-phase of catalyst, oil and gas exist. The density distribution of riser can give important information of catalyst distribution which is a measure of reactivity.

2.1 methods

To apply the 4th generation scanning geometry for the riser, 24 detectors (Ludlum 44-62) were installed on a stationary ring and connected to data acquisition system. 150 mCi of ^{60}Co source was used for experiment. ^{60}Co has been widely used in industrial application and emits 1.17 and 1.33 MeV gamma. ^{60}Co can be regarded as one of best option for industrial scale tomography. The radiation from ^{60}Co is emitted through the window of tungsten collimator. The collimator is to confine the beam to scanning plane. The source moves through the track during the measurement. The source moving track and detector mount were designed for in-site installation around the riser because the on-site installation is more applicable in industries. The source moved step by step along the rotator ring by 72 steps. Radiations were measured in gross counting mode at each detector. Fig. 3 shows the diagram of measurement geometry.

Fig. 2 Photos of field experiment of 4th generation geometry by instant installing of system

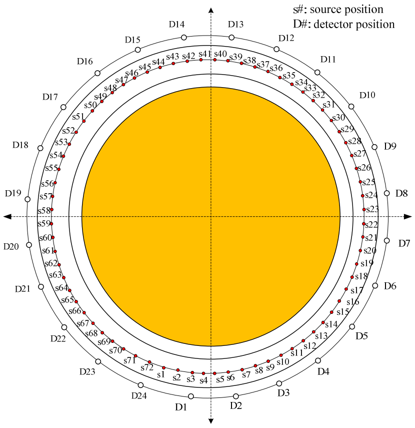

Fig. 3. Measurement geometry for riser

2.2 results

Tomographic data consist of mass thickness measurement data in different directions. Prior to the image reconstruction, measurement data can be re-sorted to check the symmetry of catalyst distribution in riser. Fig. 4 shows the projection data which were re-sorted for the same relative position of source and detector.

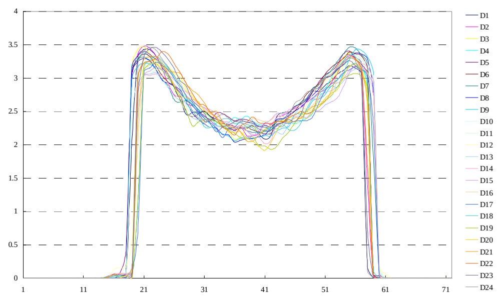

Fig. 4. Projection data for same relative position of source and detectors

Fig. 5 shows the image reconstruction result by ART algorithm [5] and the contour mapping image. The image reconstruction result presented the information of operation condition for radial distribution and angular distribution of catalyst. The result shows that the angular distribution is homogenous. And radial distribution has low density in center and high density in wall side. This phenomenon happens because the velocity of center is faster than that of wall side.

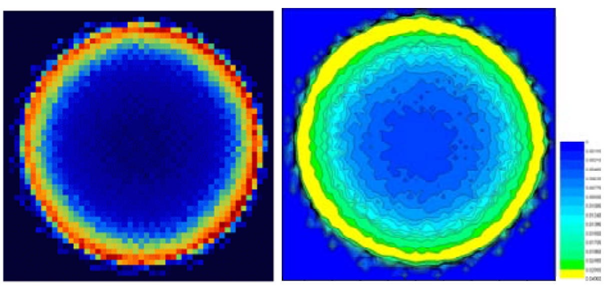

Fig. 5. Image reconstruction result by ART(left) and contour mapping image(right)

4. Conclusions

As this work focused on feasibility test on 4th generation gantry for large scale industrial plant, the system configuration has started with individual gamma ray detectors without development of the exclusive detection system. In the long term, the development of a high resolution detection system would be necessary for more detailed inspection because the output image is deeply subject to the number of detector bins and their size. Based on experimental data, the conclusion to be drawn here is that this work demonstrates the feasibility of a 4th generation scanning system for real scale tomographic scan and its result was promising.

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