# Development of industrial gamma CT system for a ring scan

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## 1. Introduction

The total size of industrial gamma CT systems proposed by researchers are much bigger than the subject itself to be scanned. It is because the radiation from a radioisotope is supposed to cover a subject at any angle [1-3].

Industrial processes are normally relatively stable for the period of measurement time, and its result is not sensitive to the length of time duration for it. As understood with 1st generation system, a CT system with single radiation source and single detector can facilitate its field applicability. In contrast to a parallel scanning method, a circular scanning system with one radiation source and one detector was proposed and tested in order to minimize the space that is needed for the measurement system while maintaining its technical performance and the spatial resolution. (figure 1)

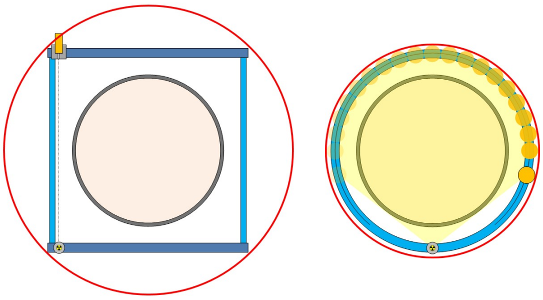

Fig. 1. Comparison of space required for measurement of 1st generation CT(left) and ring-scan CT(right)

## 2. Methods and Results

### *2.1 Hardware design*

Fig. 2 shows the drawing of a circular scanning system with one radiation source and one detector. In this scanning geometry, a guide ring is fixed to the measurement object, the radiation source and detector move along the guide ring. The radioisotope is contained in cylindrical collimator which is made of tungsten. The source collimator is designed to emit fan beam of 90 degrees with narrow window. 2 inch NaI(Tl) coupled with digital gamma spectrometer was used. The detector is mounted vertically on a detector collimator with a 5mm diameter hole. A detection unit consists of two servo motors. One of motors is responsible for revolution of the detection unit, the other is responsible for rotation of the detection unit. The detection unit can move ±90 degrees from opposite side of the radiation source. Depending on size of object, the moving angle can be adjusted. The detection unit is adjusted so as to face the radiation source at each step.

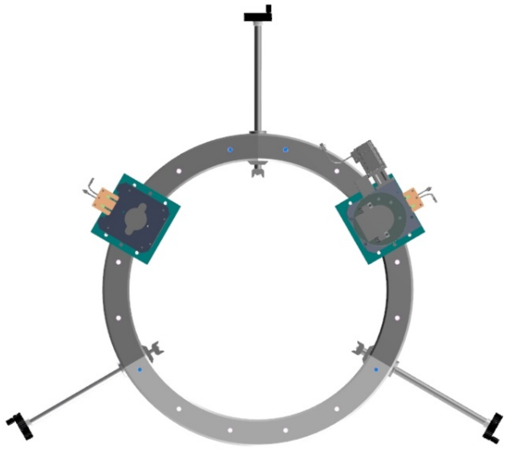

Fig. 2. CAD drawing of ring-scan gamma CT

### *2.2 Experimental setup*

To generate tomographic data, the source rotated with 180 steps through 360 degrees along the guide ring. The detector moved a total 108 degrees by 1 degree on the opposite side of the radiation source. As shown in figure 3, the experiments were performed for phantom made of 16 objects of different sizes and densities such as PE, Teflon, aluminum and iron. In the tests, 15mCi of $^{137}Cs$ was used as the gamma-ray source. Radiations were measured in photopeak counting. The counting time was 5 seconds at each measurement.

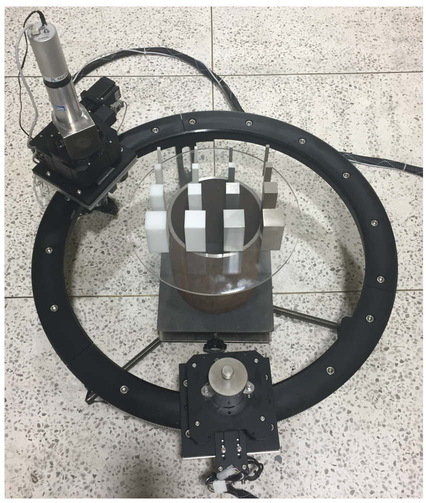

Fig. 3 Experimental setup

### *2.3 Measurements and image reconstruction*

Image reconstruction results based in the above described iterative algorithms will be presented. These results are based on a reconstruction of a 64 X 64 matrix with 180, 90, and 45 projections. In Fig. 4. results are shown for comparing between EM [4] and POCS-TV [5] reconstruction algorithm. To the left is shown the reconstructed image using FBP algorithm.

With the image using FBP algorithm, figure 4- (a), (d) and (g), it is clearly seen that the increased number of the projections improve the reconstructed image quality especially the image of contrast and resolution. The reconstructed images with 180 projections have less streak artifact compared with images with 90 and 45 projections. When only 45 projections were used for reconstruction, severe streak artifact occurred so that the entire shapes of objects were hard to recognize. Even the smallest objects at 4th row could not be distinguished from the background artifacts.

When the number of projection is sufficient, such as 180 projections, the image quality is similar according to the reconstruction algorithm. However, the projection data is insufficient and the number of projection is sparse, the images reconstructed by iterative reconstruction, EM, and POCS-TV, have far better image quality than the images by analytic algorithm, FBP. As the image (h), and (i) in figure 4. are shown, with a quarter of 180 projections, the smallest objects of the last row is reconstructed and the streak artifact is reduced.

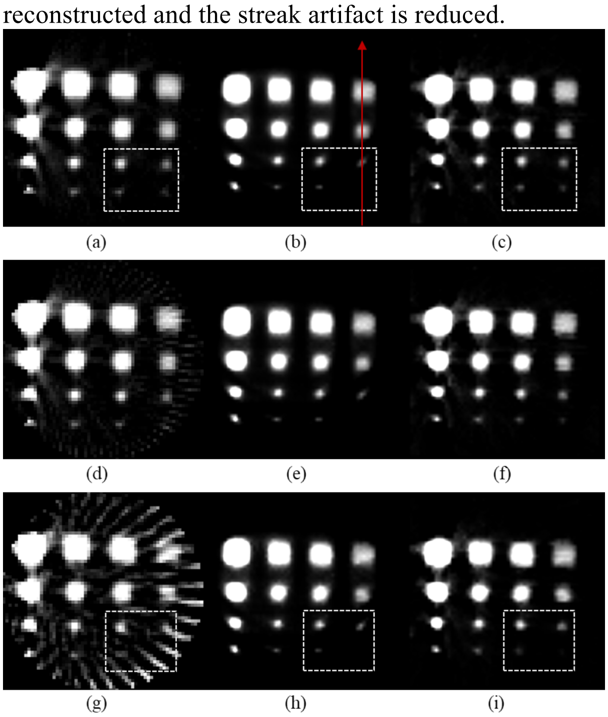


Fig. 4. Reconstructed images of the phantom are shown with different number of projections and reconstruction algorithm. The number of projection used for reconstruction is 180, 90, and 45 according to the row. (a), (d), and (g) reconstructed by FBP, (b), (e), and (h) reconstructed by EM, and (c), (f), and (i) reconstructed by POCS-TV.

## 3. Conclusions

A ring-scan gamma tomographic system that minimize the space required for scanning has been developed. Laboratory experiments with developed tomographic system have been carried out. Different image reconstruction algorithms were evaluated for measurement conditions. The results show that EM and POCS-TV have good image results. From those result, this study successfully demonstrates that gamma-ray tomography for a ring-scan can provide preliminary result for development of real system. Experiments with higher energy source of Co-60 (1.33 and 1.17 MeV) for industrial plant will be carried out in future work.

## REFERENCES

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