PMMA-based Anti-scattering Grid Performance Test by MCNP Code Simulation

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1. Introduction

In radiography system, there are two points to be considered. The first one is image quality. The image quality (or contrast) is very important to diagnose a disease correctly. The second one is patient dose. If one takes a radiographic image with high voltage X-ray source to get a high contrast image, the patient may take too much dose from it.

The X-ray anti-scattering grid is equipped in radiography image in order to improve the image quality [1]. However, the grid makes an image quality high but also patient dose increasing. The grid not only reduces scattered photons but also primary photons which are related to number of data. Therefore, the optimization of anti-scattering grid is needed to minimize the patient dose and increase the image quality.

In this study, the performance test of anti-scattering grid was conducted by MCNP code simulation [2]. The method of test was based on an international standard; IEC 60627[3].

2. Methods and Results

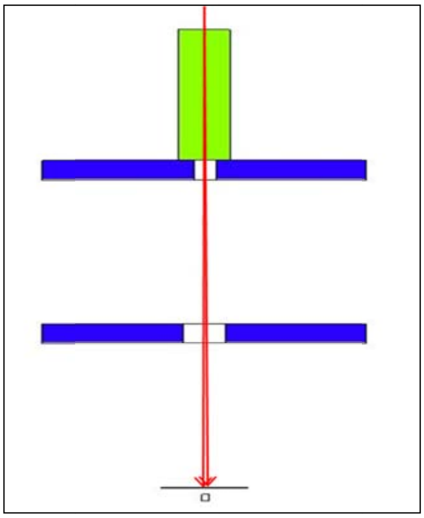
In this section, the method of simulation and analysis are described. Geometry of the simulation was based on the IEC 60627. Method of analysis was based on the reference paper [4].

2.1 Design of simulation

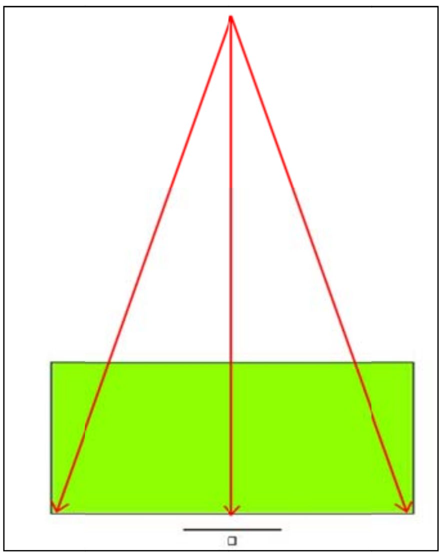
The simulation geometry was based on the international standard, IEC 60627: Diagnostic X-ray imaging equipment – Characteristics of general purpose and mammographic anti-scatter grids. It includes the basic concept of performance of anti-scattering grid and how to measure it.

Fig. 1 shows the geometry of the simulation. Fig 1. (a) shows the simulation geometry for primary photon. The primary photon is defined as the photon from the source which have been not scattered before it enters a detector. The green box represents small phantom which induce the photon scatter and absorption. The blue part is a lead plate to collimate photons exited from the phantom. Fig 2. (b) shows the simulation geometry for total photon. Total photon includes both primary and scattered photon.

The source was cone-shape 60 keV photon. The central angle of cone for primary and total photon was 0.573 and 8.53 respectively. A small square at the bottom of the figure is a detector. The detector was ideal cylinder detector which has radius of 3 mm. The data was acquired from top surface flux of the cylinder detector. The line above the detector is the anti-scattering grid. A design of the grid is described in next section.



(a)



(b)

Fig. 1. Geometries of the simulation. (a) Geometry for primary photon and (b) Geometry for total photon.

2.2 Design of grid

Four types of grid were tested in this study. Basically, all grids were designed with lead shielding material and PMMA (Poly methyl methacrylate) interspace material.

The lead shielding wall was inserted into the PMMA interspace material. Fig 2 shows the cross sectional views of the designed grids. In fig. 2, the red part represents PMMA, the interspace material and the blue part lead, the shielding material.

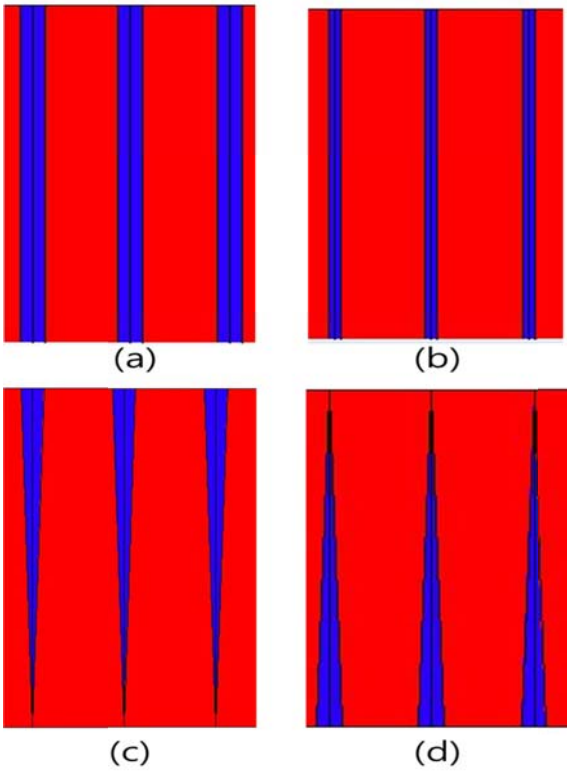


Fig. 2. Cross sectional views of the designed grids. (a) Thick parallel type,(b) Thin parallel type, (c) 'V' type, (d) 'Inverse V' type

Fig. 2. (a) represents the thick parallel type which had shielding wall thickness of 20 µm. Fig. 2. (b) represents the thin parallel type which had shielding wall thickness of 10 µm. Fig. 2. (c) and (d) represents 'V' type and 'inverse V' type respectively where a thick part of shielding wall was 20 µm. All the types had same shielding wall line density of $125/cm^{-1}$. The aspect ratio of shielding wall was calculated as height of shielding wall divided by a length for the thickest part of shielding wall. Therefore, the thin parallel type had twice bigger aspect ratio of shielding wall than other types where other types had same aspect ratio of shielding wall.

2.3 Results

In Fig. 3, the better performance for a grid was achieved as the number of the contrast improvement factor was increased according to the increasing of Bucky factor [4]. Also, the grid of the thin parallel type was shown to have the highest performance while that of the thick parallel type showed the lowest performance for the same Bucky factor. By comparing the contrast improvement factors between grids with thick and thin parallel type, the change of the aspect ratio of the shielding wall affected the gird performance much when the line densities of the shielding wall were same. Also, in Fig. 3, the grid of 'V' type or 'inverse V' type (not parallel but inclined) for the shielding wall showed better performance than that of thick parallel type Therefore, the grid with the shielding wall of 'V' shape could be replaced taking into the fabrication account.

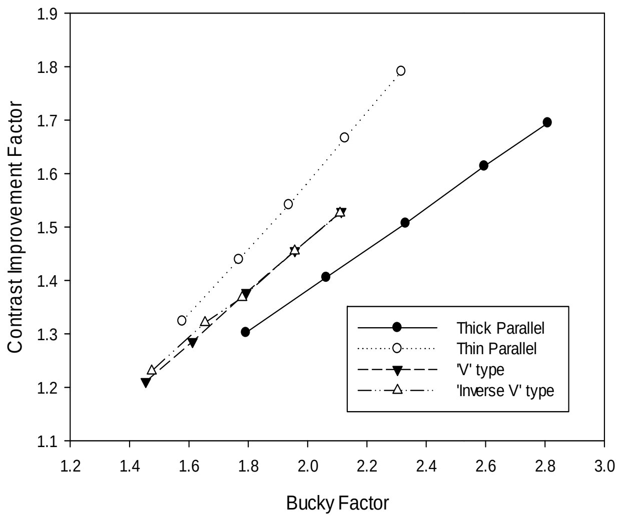


Fig 3. The contrast improvement factor according to the change of Bucky factor

3. Conclusions

The performance test of PMMA-based anti-scattering grid was carried out. It was understood that the grids with types of 'V' or 'inverse V' type showed better performance than that of the parallel type for the same aspect ratio of the shielding wall. Whereas if the aspect ratio was much bigger, the grid of the parallel type was expected to have better performance giving the high contrast improvement factor. Consequently, the aspect ratio of the shielding wall was shown to be the dominant factor affecting on the grid performance even though it was hard to fabricate the grid of the parallel type with high aspect ratio. It was understood that the grid of 'V' or 'inverse V' type could be the replacement of that of the parallel type due to their better performance than parallel one.

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