Development of a Modified Reconstruction Algorithm for 90-Degree Compton Scattering Imaging

Sang Hoon Lee
Innovative Technology Center for Radiation Safety (iTRS)
17 Haengdang, Sungdong, Seoul, Korea 133-791

Tran Kim Tuan, Jong Kyung Kim
Department of Nuclear Engineering, Hanyang University
17 Haengdang, Sungdong, Seoul, Korea 133-791

Sung Ho Park
Hallym University Sacred Heart Hospital
Anyang, Kyunggi, Korea 431-070

Abstract

A modified reconstruction algorithm has been developed for an X-ray luggage inspection modality based on 90 Compton scattering imaging. Incident photon energy E0 of 122.1keV was used in simulated experiments with MCNP for 5x5x5 samples and the 90 Compton scattered photon energy E1 is 98.6keV. In the it(E1) reconstruction calculation the least-squares solution was computed through Householder transformations applied in blocked form for the full it(E1) over-determined system equations of the side detector responses in the simulated experiments. In the it(E0) ic(E0) reconstruction calculation, instead of it(E0) = ic(E0) approximation which does not hold true for the source energy of this paper, the semi-empirical formula it(E0) = d* ic(E0)+ e* it(E1) was used and the least-squares solution was computed with the conjugate gradient method for it(E0) ic(E0) system equations of the side and transmission detector responses and the semi-empirical formulae. Self attenuation correction factors in a simple form were applied in an iterative manner until the factors and reconstruction output are converged. The maximum errors of the reconstruction calculation for a sample with aluminum core and polyethylene matrix were -2.9% for it(E0), -1.0% for it(E1), and 1.9% for ic(E0), showing good agreements with theoretical values. The maximum errors for the case with steel core and polyethylene matrix were -10.2% for it(E0), -3.3% for it(E1), and 20.3% for ic(E0), indicating that this case with 3 cm steel rod would be a limiting case for the penetration ability of 122.1keV incident photons used in the inspection modality.