ABSTRACT

X-rays are high-energy electromagnetic radiation widely utilized in the medical field, particularly for diagnostic radiography, CT scans, and cancer therapy. The development and optimization of X-ray systems are crucial to support demands in both medical and industrial sectors. However, experimental research on such systems often faces obstacles, including high costs, limited access to equipment, and low flexibility in parameter adjustments. Monte Carlo-based simulation offers an effective and efficient solution to overcome these limitations. This study aims to benchmark the energy spectrum of an X-ray system simulated using the Monte Carlo method with the MCNP (Monte Carlo N-Particle) software and compare it with results from the SpekCalc simulation program. The simulation was conducted using a Siemens P135/30R X-ray tube model with variations in tube voltage (60–130 keV) and detector distance (70–130 cm). The X-ray spectrum from SpekCalc was obtained at a fixed distance of 100 cm from the source, while in the MCNP simulation, the most similar spectral shapes were found at distances of 115–125 cm for the same energy range. The simulation results were analyzed using spectrum graphs, absolute photon deviation values, and average deviations to determine the most representative detector distance compared to the SpekCalc spectrum. Additionally, a linear correction equation was obtained for the detector distance in the MCNP simulation of the bremsstrahlung X-ray spectrum: y=0.1667x+5.4167. This equation indicates a linear relationship between tube voltage and the correction factor for detector distance in the simulation. The results demonstrate that MCNP can accurately reproduce the X-ray spectrum and can be used as a benchmarking tool in the development of X-ray systems.

Keywords: *MCNP, Monte Carlo, SpekCalc, X-ray tube, benchmarking, bremsstrahlung spectrum*