SYNOPSIS

Adequate Non-Destructive Techniques (NDT) are required for ensuring the quality and maintenance during manufacture, construction and operation stages in any industry, therein reducing the operating cost and investment. Among various NDT techniques, gamma scattering method is highly useful due to its non contact and single sided access advantages. However, the complications due to attenuation effects, multiple scattering and the resultant difficulties in reconstruction make this technique more uncommon. The aim of this study is to identify some of the attractive applications of the gamma scattering technique for Non-Destructive Evaluation (NDE) and to provide simple recipes for attenuation correction, multiple scattering correction and density reconstruction. A comparison of gamma scattering technique with transmission method is also carried out. All the experiments are performed with an indigenously developed automated experimental setup consisting of a high resolution High Purity Germanium (HPGe) detector and collimated radioactive sources ($^{137}\text{Cs}$, $^{241}\text{Am}$). The system can function in both transmission and scattering modes simultaneously. The scattered and transmitted intensities of the sample under investigation are obtained from the area under the corresponding peaks in the pulse height spectra. These intensities are related to the density of the sample. Hence, any variation in density or presence of defect reflected in these intensities and quantification of defects is carried out by using these intensities. The experimental results are supported by those simulated using Monte Carlo N Particle (MCNP) code. The following cases are investigated. The corrosion detection in mild steel and intercomparison of results obtained by gamma scattering, gammatography and radiography techniques is carried out. The minimum detectable limit of thickness loss is 1.4 mm. The fluid-fluid, fluid-air interface level detection and density determination by gamma scattering method and inter comparison with transmission (gammatography)
technique is carried out. The obtained accuracies and resolution of the level detections and density measurements are higher in case of gamma scattering method compared to transmission method. An improved gamma scattering method for determination of concentration of low atomic number solutions is presented. A nonlinear relation between the gamma scattered intensity and the sample radius including the attenuation and multiple scattering contributions was suggested in this work. The scattered intensity per electron from fluid samples of various scattering volumes were simulated using MCNP code and they varied according to the prescribed nonlinear relation with an accuracy $R^2$ greater than 0.90. The density values obtained by extrapolating the above nonlinear fit were in good agreement with that of standard densities. The application of gamma scattering technique to detect voids embedded in concrete blocks and their characterization is demonstrated and this technique could locate the hidden and surface voids of various sizes ranging from 0.5 - 3 cm diameter from the intensity profile. A simple algorithm for density reconstruction for any scattering angle from the scattered intensities is developed. The algorithm is verified by reconstructing the densities from the scattered intensities obtained from a homogeneous concrete block of density 2.24 g/cm$^3$ and the resultant mean density is 2.2217 g/cm$^3$. The utility of gamma scattering technique to quantify the water (moisture) content in concrete is tested and good agreement with the gravimetric and transmission methods is obtained within accuracy of 10%. The superiority of gamma scattering NDE technique over transmission technique for low atomic number samples is explored in detail in the present study. The theoretical calculations and algorithms described are simple and easy to execute. These studies could emphasize clearly the importance of scattering technique in NDE applications and the improvements required for the experimental system for achieving higher accuracy and portability.