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DEVELOPMENT OF AN IRRADIATION SYSTEM FOR PRODUCTION OF GASEOUS RADIOISOTOPES AND OF A TOMOGRAPHIC 2-D GAMMA SCANNING FOR INDUSTRIAL PROCESS TROUBLESHOOTING IN BRAZIL

Radioisotopes as radiotracers are used in analytical procedures to obtain qualitative and quantitative data systems, in physical and physicochemical studies transfers, and troubleshooting of industrial process plants in chemical and petrochemical companies. In the production of gaseous radioisotopes used as tracers in industrial process measurements, argon-41 (41Ar) and krypton-79 (79Kr) stand out because each has low reactivity with other chemical elements. 41Ar is a transmitter range with high-energy (1.29 MeV) and a high percentage of this energy transformation (99.1%), resulting in relatively small quantities required in relation to the other, for an efficient detection, even in large thicknesses components. In this sense, the aim of this study is to develop an irradiation system for gaseous radioisotope production in continuous scale, applied in industrial applications of emission tomography and flow measurement. The irradiation system may produce 41Ar with activity of 7.4×1011 Bq (20 Ci) per irradiation cycle, through the Reactor IEA-R1 with 4.5 MW and average thermal neutron flux of 4.71×1013 ncm−2s−1 to meet an existing demand in NDT and inspections companies, and even needed by the Radiation Technology Centre, at IPEN/CNEN. The irradiation system consists of an aluminium irradiation capsule, transfer lines, needle valves, ringed connections, quick connectors, manometer, vacuum system, dewar, lead shielding, storage and transport cylinders, among other components. The irradiation system was approved in the leakage and stability tests (bubble test, pressurization, evacuation and with leak detector equipment. In the experimental production obtaining 1.07×1011 Bq (2.9 Ci) of 41Ar, alanine dosimeters were distributed into various components of the irradiation system. In addition, exposure rates were determined in the lead shielding wall, in which the liquefied radioactive gas was concentrated, and in the storage and transport cylinders after 41Ar was transferred by the portable radiation meter.

However, gamma scanning is a nuclear inspection technique widely used to troubleshoot industrial equipment in refineries and petrochemicals plants such as distillation columns and reactors. A sealed radiation source and detector move along the equipment, and the intensity readouts generate the density profile of the equipment. The result of gamma scan still consists of a simple 1-D density plot. In this work, we also present the tomographic gamma scanning that, using image reconstruction techniques, shows the result as a 2-D image of density distribution. Clearly, an image reveals more features of the equipment than a 1-D graph and many problems that could not be troubleshooted using the conventional technique can now be solved with this imaging technique. We use ART (Algebraic Reconstruction Technique) intercalated with total variation minimization filter. The use of total variation minimization leads to compressive sensing tomography, allowing to obtain good quality reconstruction from few irradiation data. We simulated the reconstruction of different density distributions. We applied the new technique to data obtained by irradiating with gamma rays phantoms that emulate industrial equipment. Finally, we present the result obtained by applying the innovative technique to real operating distillation column.

Keywords: Irradiation system, gaseous radioisotope production, argon-41, industrial process measurement, gamma scanning, industrial tomography, distillation column, algebraic reconstruction technique.

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