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Use of Detectors Technology for Gamma Ray Issued from Radioactive Isotopes and its Impact on Knowledge of Behavior of the Stationary Case of Solid Phase Holdup

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Abstract**—**For gamma radiation detection, assemblies having scintillation crystals and a photomultiplier tube, also there is a preamplifier connected to the detector because the signals from photomultiplier tube are of small amplitude. After pre-amplification the signals are sent to the amplifier and then to the multichannel analyser. The multichannel analyser sorts all incoming electrical signals according to their amplitudes and sorts the detected photons in channels covering small energy intervals. The energy range of each channel depends on the gain settings of the multichannel analyser and the high voltage across the photomultiplier tube. The exit spectrum data of the two main isotopes studied ,putting data in biomass program ,process it by Matlab program to get the solid holdup image (solid spherical nuclear fuel) .

Keywords**—**Multichannel analyzer, Spectrum, Energies, Fluids holdup, Image

I. Introduction

A scintillator is material which exhibits scintillation which is the property of luminescence [1] .When excited by ionizing radiation, luminescent materials when struck by an incoming particle absorb its energy and scintillate or reemit the absorbed energy in the form of light [2]. Sometimes, the excited state is metastable, so the relaxation back out of the excited state is delayed depending on the type of transition and the wavelength of the emitted optical photon. A scintillation detector or scintillation counter is obtained when a scintillator is coupled to an electronic light sensor such as a photomultiplier tube or a photodiode. photomultiplier tube absorb the light emitted by the scintillator and reemit it in the form of electrons via the photoelectric effect. The multiplication of electrons results in an electrical pulse which can then be analyzed and yield meaningful information about the particle that originally struck the scintillator.. The first device which used a scintillator was built in 1903 used a ZnS screen [3]. The scintillations produced by the screen were visible to the eye if viewed by a microscope in a darkened room, the device was known as a spinthariscope. The technique led to a number of important discoveries [4] . Scintillators gained additional attention in 1944, when Curran and Baker replaced the naked eye measurement with the newly developed PMT [5], [6], and [7].

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II. Procedure

There are a total of 30 detectors being used in this setup, 15 detectors are set up to detect Cs-137 activity of 100mCi and 15 detectors are to detect Co-60 with 50mCi in transmission measurement geometry. The arrangements of the detectors are made such that they form two sets of curved detector arrays.

With this arrangement, it is expected that the dual source computed tomography could perform CT scan for an 18 inch column. For smaller columns sizes like 10- 12 inch may need 9 or 11 detectors only. In addition, equal number of detectors should be taken out from left side and right side so as to keep the fan beam measurement. With odd number of detectors, it is convenient to identify the center of detectors that is directly opposite to source point. The scintillating detector is Saint Gobain's Model 2M2/2-X, a 2 inch x 2 inch NaI(Tl) and is coupled to CANBERRA Model 2007 Pre-amplifier. All detectors are supplied with 900V from three units of high-voltage HV distributor, which gets its power from six units of CANBERRA Power Supply Model 3002D (0-3kV). Signal outputs from the detectors are then fed into four units of pulse-processing units, where each unit can accept up to eight inputs. The present arrangement uses two units on the left for 15 detector signals that detects Cs-137 source and two units on the right are for 15 detectors signals that detects Co-60 source. For ease of description, detectors that detect Cs-137 peaks shall be called Cesium detectors and detectors that detect Co-60 peaks shall be called Cobalt detectors. Connection cables for HV are RG 59B/U 1C 23AWG and signal cables are RG 174/U. The schematic of detector assembly is shown in Fig 1.

III. Results

A. Exit peaks of Cesium and Cobalt isotopes from five detectors

From the excel sheet we need range of the energies at which the peaks of Cesium and Cobalt exist, these energies are needed as input in the scan program called biomass. For Cesium make a table consisting of 3 columns and rows of unblocked detector as shown in table 1, then note the start and end value of the peak of each detector, let some small clearance from the left of the start peak and the right of the end peak and record . For Cobalt, make a table consisting of 4 columns and rows inputting three values not two as shown in Table 2. In this case the first value corresponds to I, second value corresponds to II and the third value corresponds for III .the spectrum exit for Cs-137 is shown in Figures 2 for test No 1 and Figure 3 for test No 2.

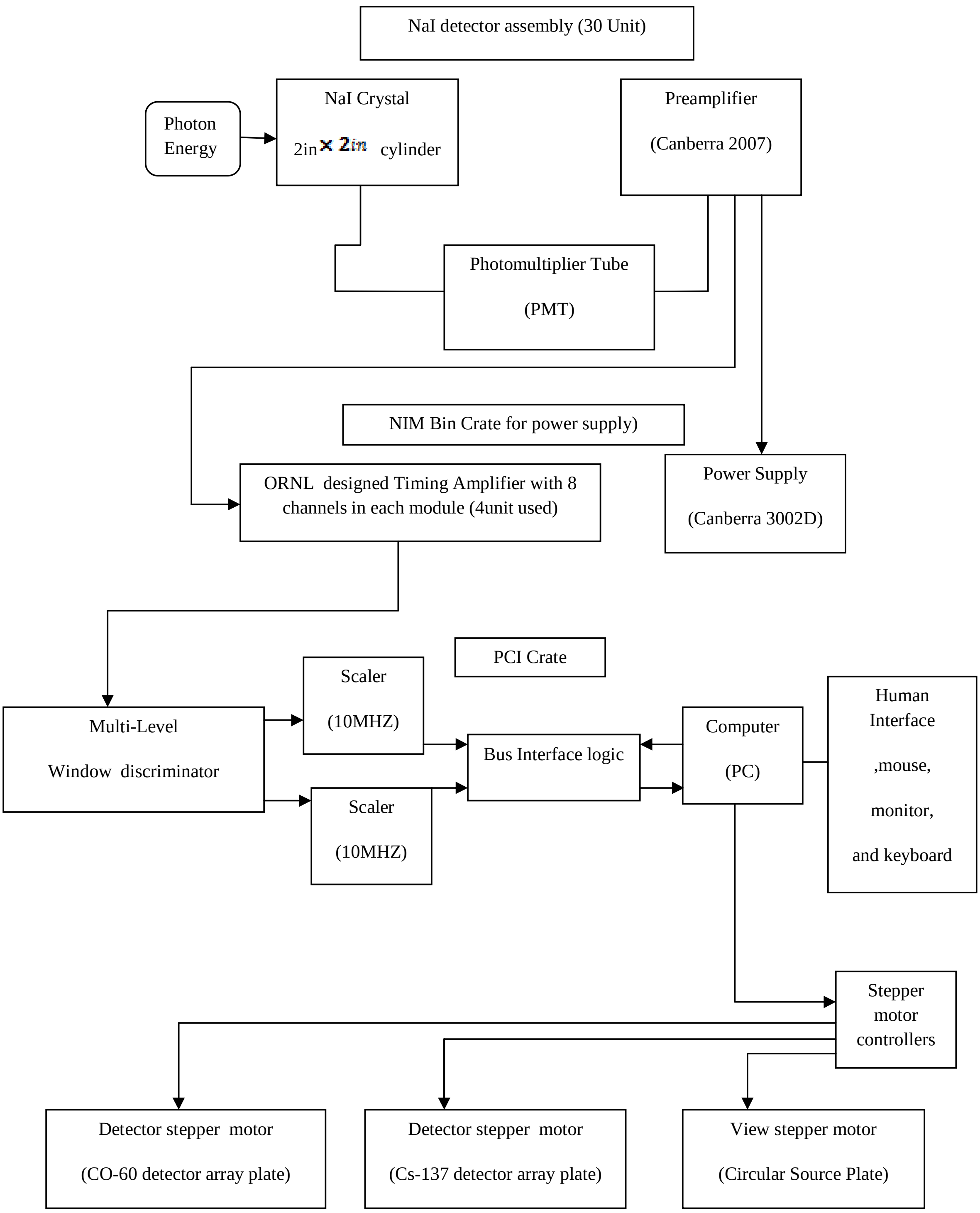

Fig. 1 Schematic of NaI detector assembly with high voltage and pulse processing system

TABLE I
START AND END VALUE OF THE PEAK OF EACH DETECTOR, AND SOME SMALL CLEARANCE OF CS-137

Detector # (Cs-137)	Start point + Clearance	End point + Clearance
1	375	500
2	400	550
16	500	600

TABLE II
START AND END VALUE OF THE PEAK OF EACH DETECTOR, AND SOME SMALL CLEARANCE OF CO-60

Detector # (Co-60)	Start point of 1st peak + Clearance	Average point between two peaks (End of 1st peak and start of 2nd peak)	End point of 2nd peak + Clearance
1	300	400	500

The spectrum indicate the following peaks ; a- Low energy of radiation due to internal conversion of the gamma ray, b- Backscatter at the low energy end of the compton distribution, the compton interaction is a pure kinematic collision between gamma ray photon and a free electron in the NaI(Tl) crystal. By this process, the incident gamma ray gives up only part of its energy to the electron. The amount given to recoil electron depends on whether the collison is head on or glancing. For a head on collision, the gamma ray imparts the maximum allowable energy for the compton interaction , c- Photopeak at an energy of 662 keV .

B. MATlab program analysis to get senogram of solid phase holdup

Peak measurement data from detectors transfer to MATlab prog .Analyzing ,the results show that for the same transmission data, the polyenergetic approach gives far superior results to the monoenergetic approach. The monoenergetic approach is sensitive because of the attenuation of the materials at the gamma ray photon energies. The polyenergetic approach based on the alternating minimization technique shows promising potential for determining the solid phase holdup using dual source gamma ray tomography .Image of senogram for pebblebed reactor with 1ft heigt and 12in diameter after 500 iterations with Hz = 5, Marbles diam=2in is shown in Figure 4, the arrangement of unit is shown in Figure 5.

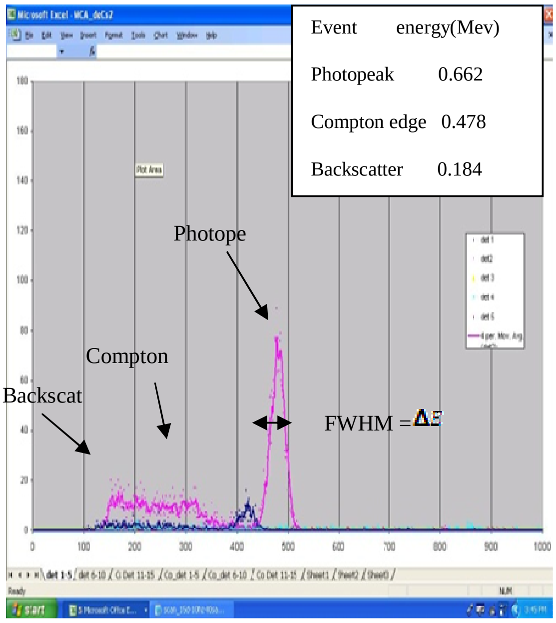

Fig. 2 Spectrum obtaining for isotope Cs-137 from five detectors ,Test No 1

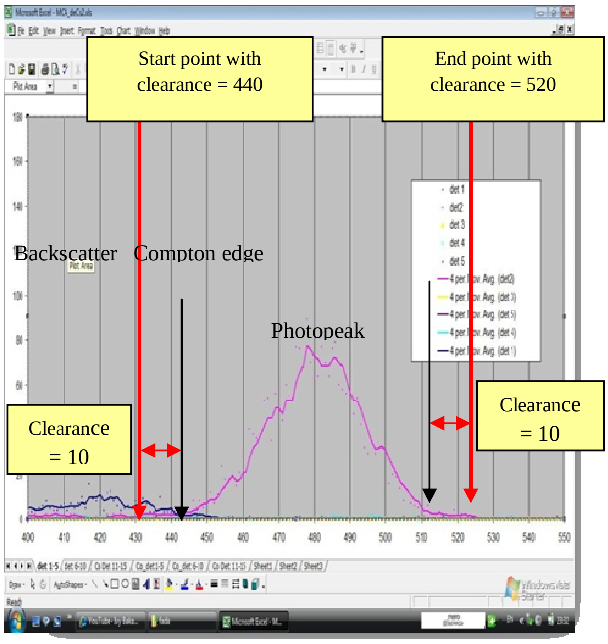

Fig. 3 Spectrum obtaining for isotope Cs-137 from five detectors, Test No 2

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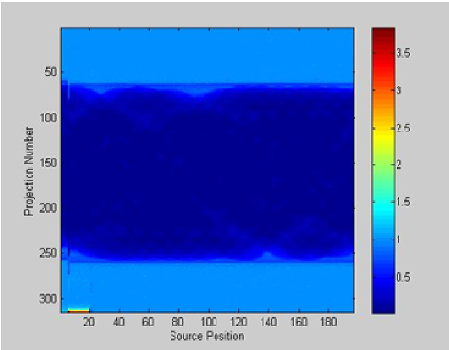

Fig. 4 Image of senogram for pebblebed reactor

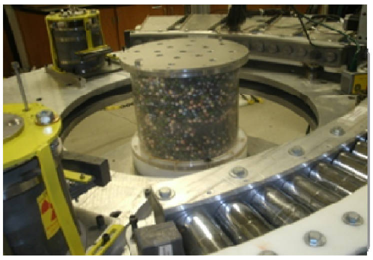
Fig. 5 Detector arrangement in tomography unit for pebblebed reactor

IV. Conclusion

Inorganic scintillators are crystals .The most widely used is NaI(Tl) scintillator detectors which has two advantages; the first; it can be produced in large crystals, yielding good efficiency, the second; it produces intense light compared to other scintillators .The spectrum measured by NaI detectors unit consist of a photomultiplier, an amplifier, and a multichannel analyzer .Inorganic crystals can be cut to small sizes and arranged in an array configuration so as to provide position sensitivity. Scintillation in inorganic crystals is typically slower than in organic ones .NaI detectors can be used in the oil industry, nuclear medicine, basic research, environmental monitoring, and aerial surveys. A systematic quantitative analysis of the senogram image generated using the alternating minimization technique .Applications that involve the use of high attenuation material, the alternating minimization algorithm is more stable and produces senogram image that have a greater degree of accuracy and lower levels of noise.

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