DETERMINATION OF UNUSUAL POSITION INSIDE A INDUSTRIAL COLUMN MODEL USING GAMMA SCANNING TECHNIQUE AT DALAT UNIVERSITY

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ABSTRACT

The gamma scanning technique has been applied in industry allowing to online determination troubleshooting and technically complex process analysis in distillation columns. In this work, we determine an unusual position inside a polyethylen column using gamma scanning technique with standard radioisotope sources 3 μCi ^{60}Co and 0.5 μCi ^{137}Cs. The results showed that the unusual position inside the industrial column model at NEF of Dalat university can be determined using gamma scanning technique in which using radioisotope source ^{60}Co for determination of the unusual position is better. The results of this work are important in supporting of basic skills for works of students in the future.

Keywords: *Gamma scanning, industrial column, polyethylene column, radioisotope source*

1. Introduction

Gamma scanning technique is a very effective technique for several types of industrial application, i.e. the optimum working of the plant production, troubleshooting and process analysisof technically complex in distillation columns [1, 2]. This technique uses a collimated beam of gamma rays which passes through the column wall. By measuring the intensity of the radiation exiting the column, one is able to determine the density of the material inside the column [3]. In the word, gamma scanning technique has been applied since 1980s [2]. At present, Vietnam has only one Centre for Applications of Nuclear Technique in Industry (CANTI). This centre has applied column gamma scanning technique in the Dung Quat Refinery for maintenance and turnaround purposes [4]. Some facilites use this technique for training as Nuclear Training Center (Vietnam Atomic Energy Institute), Department of nuclear physics-nuclear engineering (Ho Chi Minh City University of Science). At present, Nuclear Engineering Faculty (NEF) of Dalat University has no equipment to experiment for this technique. So the purpose of this study was to design and install a equipment (Fig 2, 3, 5 and 6) that can determine an unusual position in a polyethylene when used gamma scanning technique with radioisotope sources of ^{60}Co and ^{137}Cs at NEF of Dalat university. The results from this

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study would serve as a basis for works of students in the future.

2. Principle of gamma scanning technique

Gamma scanning technique is based on the principle of attenuation of gamma ray intensity between the radioactive source and detector described by the transmission law irradiation is calculated by expressions [5, 6]:

$$I = I_0 \exp(-\mu\rho x) \quad (1)$$

Where I is intensity of radiation transmitted through the material; $I_0$is intensity of incident radiation; μ is the mass absorption coefficient of the material (cm^2/g); ρ is density of material (g/cm^3); and xis material thickness (cm).

By placing the collimated gamma source and radiation detector oppositely to the object, the variation of gamma intensity obtained at the gamma detector shall provide the information of inner objects. Principle of gamma scanning technique is showed in Fig 1.

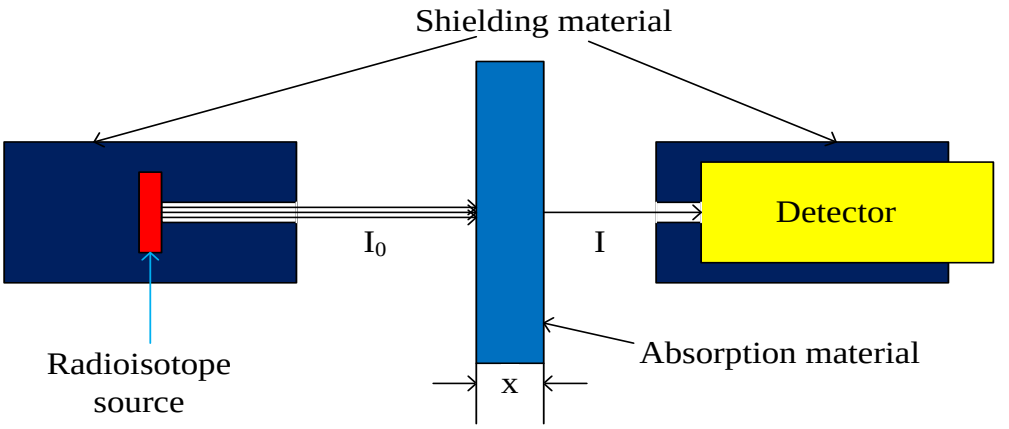

Fig 1: *Principle of gamma scanning technique*

3. Experimental

3.1. Radioisotope source box and collimator

A cylinder shaped radioisotope source box of outer diameter 4.5 cm; height 8.0 cm and inner diameter 2.7 cm was made steel. The top cover of the box was designed with collimators for changing of width of radiation beam. Each collimator has cylinder shape of outer diameter 4.5 cm and height 2.0 cm; and inner diameters are 0.5 cm; 1.0 cm; 1.5 cm and 2.0 cm. Figures of radioisotope source box and collimators in this experiment is shown in Fig 2 and Fig 3.

Fig 2: *The radioisotope source box at NEF of Dalat university*

Fig 3: *The collimators for radioisotope source at NEF of Dalat university*

3.2. Radioisotope sources

In view of gamma scanning technique, standard radioisotope sources of 1 μCi ^{60}Co and 0.25 μCi ^{137}Cs wereused for this experiment. Parameters of the radioisotope sources are presented in Table 1.

Table 1: *Parameters of the radioisotope sources at NEF of Dalat University used for this work*

Radioisotope source	Radioactivity	Manufacture year	Eγ (keV)
^{60}Co	1 μCi	1/2014	1173 và 1332
^{137}Cs	0.25 μCi	12/2013	661

3.3. Detector for gamma ray detection

In order to measure gamma rays in this work, a gamma-ray detector (Spectech, ST360 Counter, USA)was used to measure the specific radioactivity of the transmission gamma rays. A cylinder shaped copper object has diameter of 3.5 cm and height of 5.0 cm, is placed at a position of 5.0 cm from bottom of the polyethylene column as an unusual position inside the polyethylene column. Figures of the gamma-ray detector and the cylinder shaped copper objectused in this work are showed in Fig 4 and Fig 5.

Fig 4: *The gamma-ray detector at NEF of Dalat university*

Fig 5: *The cylinder shaped copper object used in this work*

3.4. Experimental setup at NEF of Dalat University

The radioisotope source and the gamma detector were arranged oppositely to the polyethylene column and moved up step by step 1 cm from bottom to the top. The polyethylene has cylinder shape of outer diameter 4.2 cm; height 30.0 cm; and inner diameter 4.0 cm. Each position of interest was scanned with time for 200 s to 1000 s. Parameters of gamma scanning time with the radioisotope sources at NEF of Dalat University are presented in Table 2.

Table 2: *Parameters ofof gamma scanning time with the radioisotope sources at NEF of Dalat University*

Radioisotope source	Number of source	Scan time (s)
^{60}Co	3	200
^{137}Cs	2	1000

The experimental setup for determination of unusual position inside a industrial column model using gamma scanning technique at NEF of Dalat University isillustratedin Fig 6.

Fig 6: *Experimental set up at NEF of Dalat university*

4. Results and discussion

The radioactivity distribution of gamma rays has been measured along the center line of the polyethylene column. Measurements have been carried out at NEF with the radioisotpe sources of 3 μCi ^{60}Co or 0.5 μCi ^{137}Cs and the collimator of inner diameter 0.5 cm. The obtained results are presented in Table 3 and the figure of these results is showed in Fig 7.

Table 3: *The result of gamma scanning measurements with the radioisotope sources at NEF of Dalat University*

Position	Counts		Position	Counts	
(cm)	^{60}Co	^{137}Cs	(cm)	^{60}Co	^{137}Cs
0	2081	1711	8	921	1178
1	1996	1723	9	984	1181
2	2058	1733	10	1623	1458
3	2023	1687	11	2066	1653
4	2042	1723	12	2079	1715
5	1293	1242	13	2059	1681
6	887	1116	14	2088	1705
7	863	1189	15	2035	1711

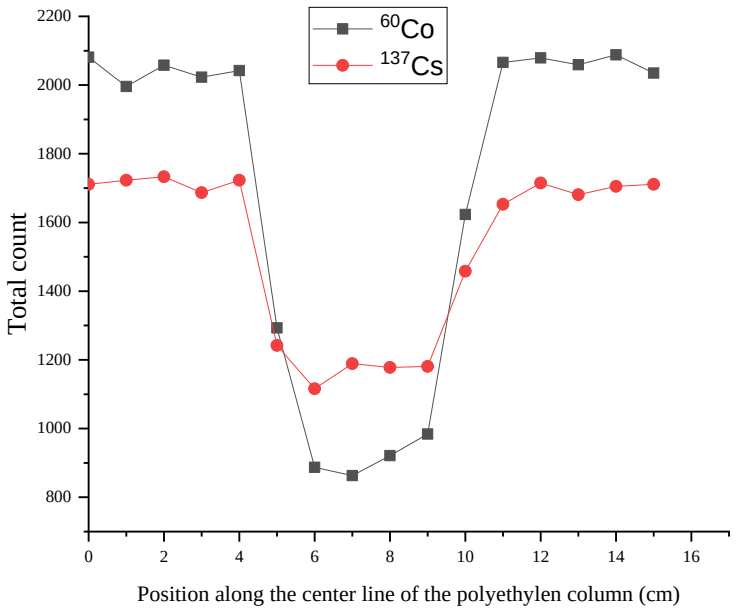

Fig 7: *The result of radioactive measurements along the center line of the polyethylene column at NEF of Dalat University*

As showed in the Fig 7, the unusual position inside the industrial column model at NEF of Dalat University can be determine using gamma scanning technique. The results shown that gamma radiation counts at the normal positions are higher those at the unsual positions about 2 times for both ^{60}Co and ^{137}Cs. In both cases, the unsual positions are determined for 4 cm to 11 cm but the reality of the unsual position is 5 cm to 10 cm. This difference can be explained by the scattering of gamma rays at the start and end positions of the copper object inside the clolumn. However, in this case using radioisotope source ^{60}Co is better because the distinction between counts is clearer and the time to experiment is less.

5. Conclusion

The gamma scanning technique has been applied to determination the unusual position inside thepolyethylene column at NEF of Dalat University using standard radioisotope sources 3 μCi ^{60}Co and 0.5 μCi ^{137}Cs. The results shown that the unsual position inside this model can be determine using gamma scanning technique. In which, using radioisotope source ^{60}Co for determination the unusual position is better. The results of this work are important in supporting of basic skills for works of students in the future.

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XÁC ĐỊNH VỊ TRÍ BẤT THƯỜNG BÊN TRONG MÔ HÌNH THÁP CÔNG NGHIỆP SỬ DỤNG KỸ THUẬT GAMMA TRUYỀN QUA TẠI ĐẠI HỌC ĐÀ LẠT

TÓM TẮT

Kỹ thuật gamma truyền qua đã được áp dụng trong công nghiệp để xác định trực tiếp các sự cố và phân tích quá trình phức tạp của công nghệ trong các tháp chưng cất. Trong công việc này, chúng tôi xác định vị trí bất thường bên trong một mô hình tháp làm bằng polyethylene, sử dụng kỹ thuật gamma truyền qua với các nguồn đồng vị chuẩn là 3 μCi ^{60}Co và 0.5 μCi ^{137}Cs. Kết quả cho thấy rằng, vị trí bất thường bên trong mô hình tháp công nghiệp tại Khoa Kỹ thuật hạt nhân - Trường Đại học Đà Lạt có thể được xác định bằng kỹ thuật gamma truyền qua. Trong đó, nguồn ^{60}Co cho phép xác định vị trí bất thường là tốt hơn. Những kết quả của công việc này có đóng góp quan trọng trong việc cung cấp các kỹ năng cơ bản cho công việc của sinh viên Khoa Kỹ thuật hạt nhân trong tương lai.

Từ khóa: *Gamma truyền qua, tháp công nghiệp, tháp polyethylene, nguồn đồng vị phóng xạ*

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