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DESIGN AND FABRICATION OF NUCLEAR RADIATION INTENSITY DETECTOR

Md Sarwar[1], M. S. Rabbi[2], and Md. Abu Hasan Al Askary[3,*]

Department of Mechanical Engineering
Chittagong University of Engineering and Technology, Bangladesh
[1]mdhsarwar@gmail.com , [2]rabbi@cuet.ac.bd , [3]*as.hasan45@gmail.com

Abstract-*Radiation damages the animal and plant cells. Low levels of radiation are not dangerous, but medium levels can lead to sickness, headaches, vomiting and fever and high levels of radiation can cause cancer and incurable diseases. So, it is important to know the level of Radiation because most of the natural and artificial materials cause radiation even the human body. This study aims to fabricate a nuclear radiation detection instrument. Three types of detectors are most commonly used, depending on the specific needs of the device. Gas-filled detector has been used in this research where air is used in the ionization chamber. A dc power source is used to generate an electric field in the chamber. When radiation enters the tube, it causes ionization, splitting gas molecules into ions and electrons. Thus, a pulse of electricity is produced and by using amplifiers these signals are being increased. By using a multimeter, the signals are detected.*

Keywords: Radiation, Detector, Gas-Filled detectors, Ionization, Signals.

1. INTRODUCTION

Radiation is a procedure of energy diffusion. When energy transfers, it can migrate like a particle or a wave. All radiation can be characterized by the electromagnetic radiation spectrum. In particular, there are two broad categories of electromagnetic radiation non-ionizing radiation and ionizing radiation. Ionizing radiation is very harmful to lives, even though it is very low in energy compared to non-ionizing radiation. For instance, both gamma rays and X-rays are ionizing radiation, and in living organisms they can cause excellent harm to cells, disrupting cell function. But microwave cannot cause ionization and cannot break atoms or molecular bonds that are typical of the molecules found in living things but can stimulate the movement of atoms and molecules that is equivalent to sample heating. On the other hand, Non-ionizing radiation is low-energy, and this is why some argue that it is secure. Health issues like cell damage, however, are not immediately seen with exposure to non-ionizing radiation but are still very much a health hazard. An increasing body of researchers think that exposure to ionizing and non-ionizing radiation over long periods. These can cause severe health problems, and present scientific studies support their concerns.

2. LITERATURE REVIEW

Theoretical calculation demonstrates that the killing of a person will require 1.5 million joules of nonionizing radiation. Ionizing radiation such as gamma rays and X-rays can kill a person with a single doseof just 300j. Everything on Earth is either natural or man-made exposed to some kind of radiation. 85.5% (natural and artificial) of complete radiation consists of 71% telluric radiation and about 14.5% cosmic radiation. Radiation, especially connected with nuclear medicine and nuclear energy use, is ionizing along with X-rays. All sources of radiation, however, do not have enough energy to communicate and generate ions with the matter, particularly the human body [1].The development of the first electronic detectors started with the invention of the Geiger-Müller tube based on gas amplification principles to measure charged particles by their ionization. Electronic detectors were equipped with more and more channels, finer granularity and fast data read-out which eventually marked the end of the big bubble chamber era. At the same time, first ideas on the use of semiconductor devices as high precision tracking detectors emerged which formed a third major detector line beside the well-established gaseous detectors and photodetectors. Today, these basic detector technologies are even combined into hybrid detector systems such as Silicon PMTs, Micro pattern Gas Detectors with Pixel Readout or Silicon Tungsten calorimeters [2]. Sung-Woo KWAK et al. developed a mobile radiation detection system against nuclear terrorism in Korea.Their experiment was to characterize the ability of their system to detect hidden nuclear and radioactive materials in a car at different speeds and different distances between the RI source carrying car and the measuring car (mobile radiation detection system) [3]. R. Brenner et al. improved the Silicon strip detector. They were capable of testing of the static parameters of the detectors. They planned and figured out the automated Lab view based on I-V, C-V, and resistance measurement strategies and tested for numerous strip detectors [4]. K. Spartiotis et al. showed the application of the created pixel detector innovation to an intraoral X-ray imaging sensor. They also contributed to the improvement of the fruitful calibration method of the sensor by presenting the 5th order polynomial first stage fit and by recommending the cooling of the detector. The authors wrote a lab view schedule for calculating the calibration coefficients for image reproduction [5]. J. Pyyhtia et al. described the issue and solution of radiation hardness of the intraoral sensor. They measured the reaction of the sensor. They also contributed to the translation of the results and to design change which driven to a rad difficult intraoral sensor [6].

3. METHODOLOGY

At first, the step process for the fabrication of this process is planned. Then a diagram of the model is being drawn. Then parts, materials, and instruments are being collected and fabricated. At last, the fabricated device is tested and compared with other models in the market to know the device working properly.

3.1 Working Procedure

First of all, taking an ionization chamber is coated by an aluminum foil so that the system is to be isolated from the environment. Then to soldier the n-p-n transistor on ionization chamber. After soldering, Resistors is soldered on the ionization chamber and is connected with n-p-n transistors according to the given figure. A 4-inch (10 cm) wire is suspended from the post inside the can. The wire length is short enough to ensure that it doesn't touch the lid. The can is connected to the positive battery voltage through a 4.7k resistor, and the meter is connected between the collector of the transistor and the positive terminal of the battery. Figure 1 shows the circuit diagram of the device. The meter is on the 1-volt scale for most measurements. After fabrication of this instrument, radioactive isotopes are being entered inside of the ionization chamber and notice the intensity of radiation on multimeter.

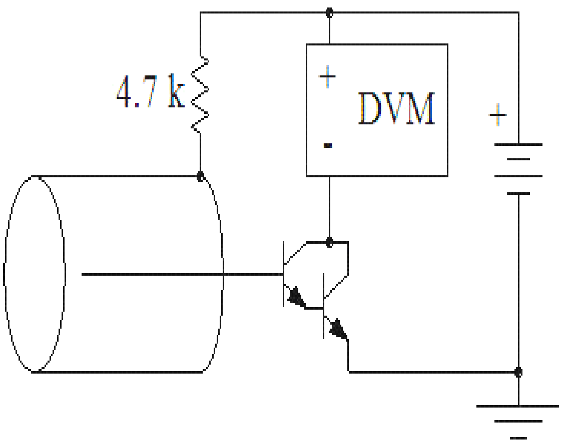
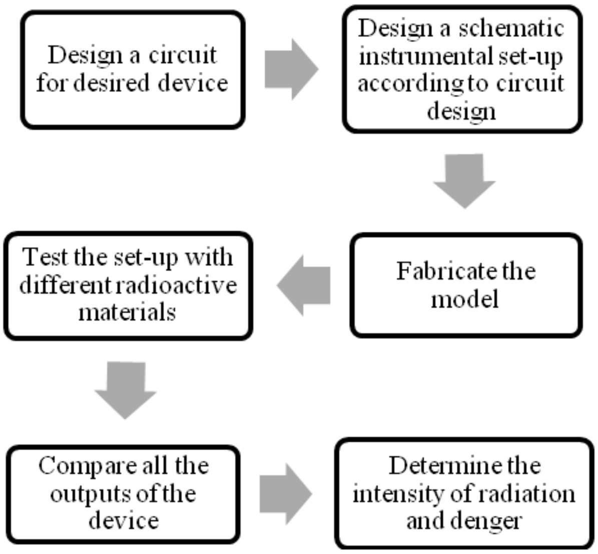


Fig. 1: Circuit diagram of the device[7].

3.2 Flow Chart for the Working Process



3.3 Fabrication of the Project

There are some components that are used in the project shown in figure 2. These instruments are ionization chamber, n-p-n transistors, multimeter, resistor, DC source, electrical wires, radioactive isotope, aluminum foil, etc. The ionization chamber is the easiest of all gas-filled detectors of radiation and is commonly used to detect and measure certain kinds of ionizing radiation; X-rays, gamma rays, and beta particles. A transistor is a semiconductor device used for electronic signals and electrical power amplification or switching. It generally consists of semiconductor material for connection to an internal circuit with at least three terminals. A resistor is a passive two-terminal electrical component that as a circuit element uses electrical resistance.Radioactive material is any material containing unstable atoms that emit ionizing radiation as it decays.

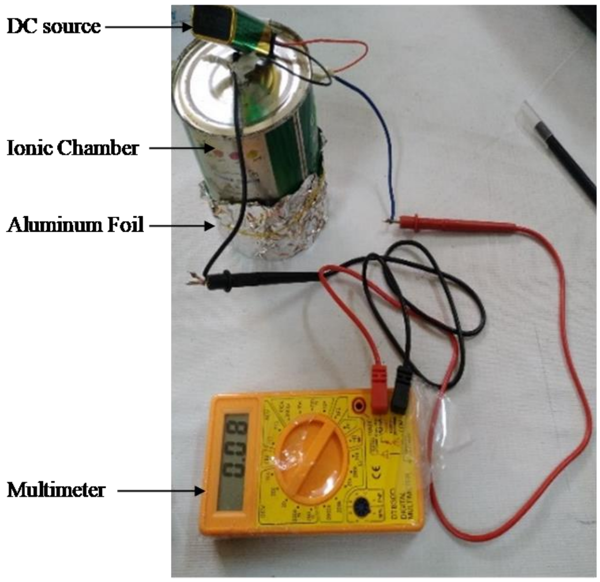


Fig. 2: Experimental setup.

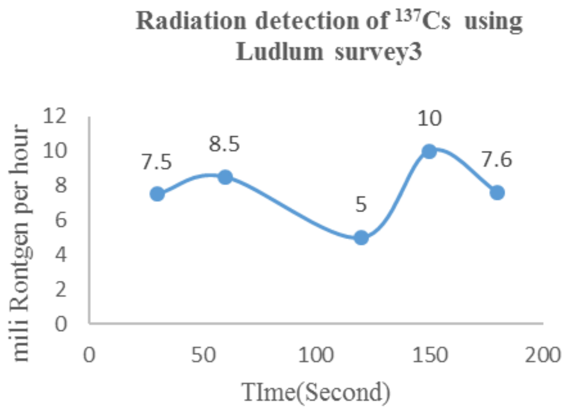
4. DATA COLLECTION AND ANALYSIS

Using two different radioactive materials are Caesium-137(^{137}Cs) and Cobalt-60(^{60}Co) isotopes. And three radioactive measurement devices are Ludlum survey model 3, PM 1401k-3 and device fabricated to do this study. Then compare the values found from the three devices to know the intensity level of the radioactivity of the two radioactive materials.

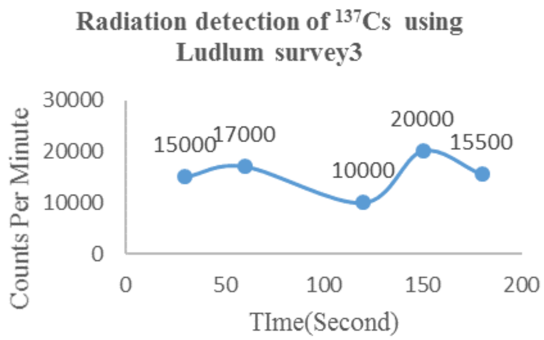
4.1 Ludlum Survey3

- Application: Alpha, Beta, and Gamma surveying.
- Linearity: Reading within 10% of true value with detector connected.
- Meter Dial: 0 - 2 mR/hr., or 0 - 500 kCounts Per Minute
- BAT TEST.
- Threshold: Fixed at -30 mV ± 10mV. [8]

Figure 3 shows the radiation detection of ^{137}Cs and Figure 4 shows of ^{60}Co using Ludlum survey 3.

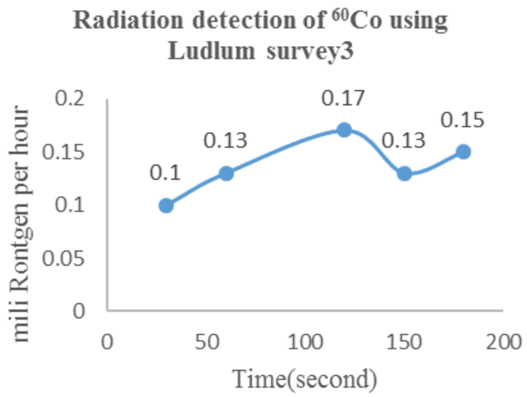


(a)

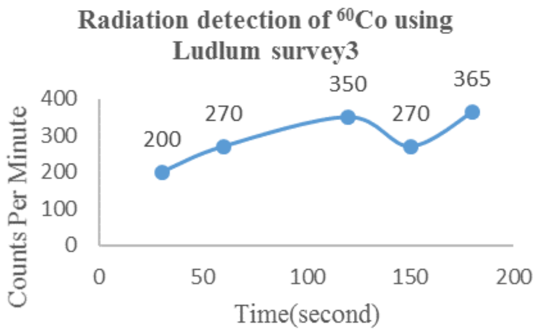


(b)

Fig. 3: Radiation detection graph of ^{137}Cs using Ludlum survey3 (a) mili Rontgen Per hour (b) Counts Per Minute



(a)



(b)

Fig. 4: Radiation detection graph of ^{60}Co using Ludlum survey3. (a) mili Rontgen Per hour (b)Counts Per Minute

4.2 PM 1401K-3

It is the world's lowest and lightest tool capable of operating concurrently as an alarming device, search device, survey meter, spectrometer, and identifier. This tool performs continuous measurement of gamma and X-ray equivalent ambient dose rates in the wide range of energy and monitoring alpha, beta and neutron.PM1401K-3E is an instrument's gamma-neutron model with no features for measuring Cs-137 activity and identifying radionuclides. PM1401K-3 M is an instrument model with no neutron detection feature that is gamma-only. Modification PM1401K-3P is fitted with integrated alpha, beta and gamma and neutron detectors (based on three scintillation units) [9].Radiation detection graph of ^{137}Cs and ^{137}Cs are shown in Figure 5 and Figure 6 respectively.

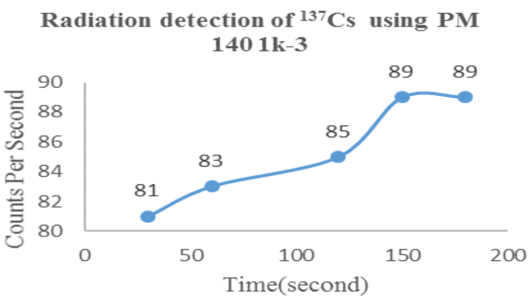


Fig. 5: Radiation detection graph of ^{137}Cs using PM 1401k-3.

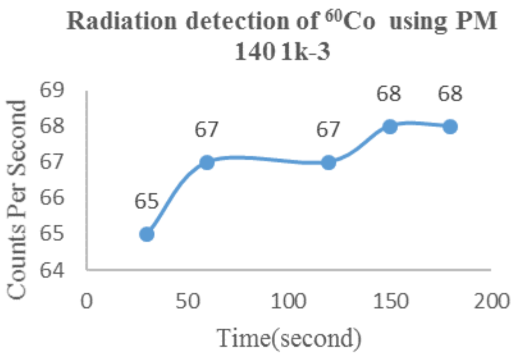


Fig. 6: Radiation detection graph of ^{60}Co using PM 1401k-3.

4.3 Fabricated Device Radiation Detection

Radiation detection graph of ^{137}Cs and ^{60}Co using inthe fabricated model is shown in Figures 7 and 8 respectively.

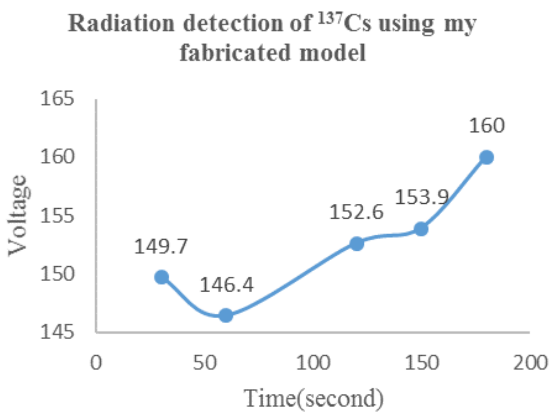


Fig. 7: Radiation detection graph of ^{137}Cs using the fabricated model.

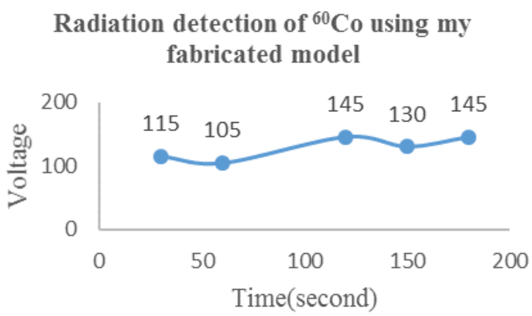


Fig. 8: Radiation detection graph of ^{60}Co using the fabricated model.

5. RESULT AND DISCUSSION

Anuclear radiation intensity detection device is fabricated in this study which is used to measure the intensity of radiation of nuclear materials Cesium and Cobalt and also justified the intensity being found is true or false by comparing the comparison values with the other two models: Ludlum survey 3 and PM 140 1k-3.

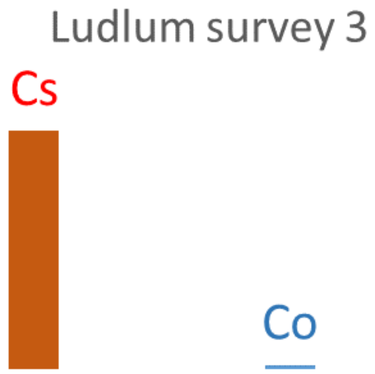


Fig. 9: Comparison of Radioactivity of Cesium and Cobalt using Ludlum survey 3.

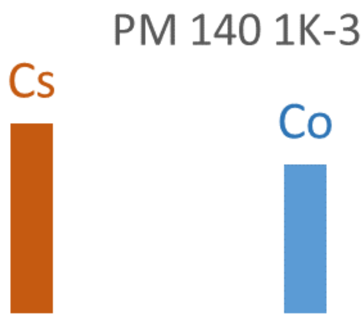


Fig. 10: Comparison of Radioactivity of Cesium and Cobalt using PM 140 1K-3.

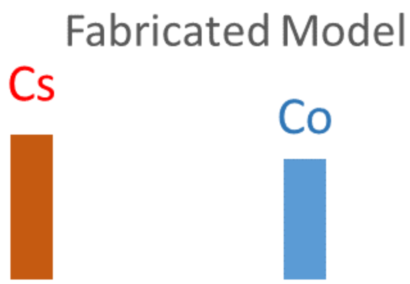


Fig. 11: Comparison of Radioactivity of Cesium and Cobalt using the fabricated device.

Figures 9, 10 and 11 show the comparison of Radioactivity of Cesium and Cobalt. From figures, finding radioactivity of cesium is higher than the radioactivity of cobalt. It can be also noted that the radioactivity intensity of cesium is higher than cobalt.

6. CONCLUSION

This study deals with the fabrication of a nuclear radiation detector and radiationdetection of radioactive materials. It is found that the radioactivity and intensity of Cesium are greater than Cobalt. Air was used in the ionization chamber as inert gas unavailable. Due to that, radiation detection was not precise. The desired transistor was not found, as a result, proper amplification did not occur. Wires were not soldiered. For these reasons, sometimes there was a huge fluctuate in values of radioactivity. The main concern was to try to design a low-cost radiation detector. This concern is fulfilled, although there is a huge scope of improvement. Aluminum fuel was used to isolate the setup from surrounding so that radiation detection of the material may more precise as the detector, in this case, will not measure environments radiation. Aluminum fuel is good for preventing alpha particles, though other things should be thought to isolate the device fully from the surrounding. The outcome of this project is satisfactory as it fulfilled the object of detection of radiation and measure its level of danger so that people will be aware of radiation around us.

7. REFERENCES

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