Investigation of Beta (β) Radiation with Absorbers of Different Thickness

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Abstract -- Inventory is a necessary evil. On the one hand it is required for the smooth production run and on the other hand it is also known as "Cancer of Industry", "Graveyard of Business", "Corporate Obesity" and "a national problem". Inventory Control is today the major profit center.This paper aims at analysis of raw materials and boiler fuel (A class items) for the development of deterministic inventory control models in a paper industry where the raw material is processed continuously through various systems. Though a number of policies are available in literature to handle inventory control situations but in paper industry, which is a big, complex and a material intensive industry, where it is difficult to control the inventory by any of the existing policies, a combination of some of the available techniques in addition to innovative control policy has been applied. The objective of the paper has been to select an appropriate policy, formulate a model and to determine its optimal solution mathematically. It was felt in the beginning of the study that improved policies could be developed only through a better understanding of the working of the existing supply and inventory management system.

I. INTRODUCTION

The word '*radiation' was* used until about 1900 to describe electromagnetic waves. Around the turn of the century, electrons, X-rays, and natural radioactivity were discovered and were also included under the umbrella of the term radiation. The newly discovered radiation showed characteristics of particles, in contrast to the electromagnetic radiation, which was treated as a wave. In the 1920s, DeBroglie developed his theory of duality of matter, which was soon afterward proved correct by electron diffraction experiments, and the distinction between particles and waves ceased to be important. Today, radiation refers to the whole electromagnetic spectrum as well as to all the atomic and subatomic particles that have been discovered.

One of the many ways in which different types of radiation are grouped together is in terms of ionizing and non-ionizing radiation. The word *ionizing* refers to the ability of the radiation to ionize an atom or a molecule of the medium it traverses.

For every atom of the source there is a probability, not a certainty, that an electron will be emitted during the next unit of time. One can never measure the "exact" number. The *number* of particles emitted per unit time is different for successive units of time. Therefore, one can only *determine* the average number of particles emitted. That average, like any average, carries with it an uncertainty, an error. The determination of this error is an integral part of any radiation measurement [1].

These are very important facts when taking the radiation measurements. Here, the nature of radiation has been studied using radioactive beta source with the aid of GM counter. Moreover, it is important to be able to gauss the danger of radiation damage when handling the radioactive sources and to take a precaution when traveling around the radioactive sources and radiated areas.

II. THEORETICAL BACKGROUND OF MEASURED SYSTEM

The theoretical backgrounds of measured system are;

(1) General Description of GM Counter

(2) Voltage Characteristic of the G. M. counter

(3) Radioactive βsource

2.1. General Description of GM Counter

In the study of radioactivity, there are usually three parameters associated with an unknown source that are necessary to know. These are: (1) What kinds of particles is the source emitting, (2) What are the energies of these particles, and (3) How many particles per unit time is the source emitting. In this experiment, the Geiger-Mueller counter (called GM) will be used to help answer the third question.

The GM tube is one of a variety of radiation detectors that take advantage of the fact that charged particles lose energy in a gas by creating electron-ion pairs. In air for example, an alpha particle will ionize from 50,000 to 100,000 molecules per cm of its path. The Geiger tube is simply a metal cylinder that is filled with some kind of counting gas. A thin window at one end of the cylinder allows the radiation to enter the counting region. When an ionizing particle (α,β) enters the counter, ionization takes place and a few ions are produced. If the applied voltage is strong enough, these ions are multiplied by further collisions. The ion-pairs that are produced by the radiation are swept out and collected by an electric field that is maintained between a thin wire on the axis of the tube (anode) and the metal cylinder (cathode). The electric field between these two electrodes is high enough that the ions produced by the initial radiation are accelerated and produce secondary ions. This phenomenon is called an avalanche. An avalanche of electrons moves towards the central wire and this is equivalent to a small current impulse which flows through the resistance. The critical potential is lowered momentarily, causing a sudden discharge through the resistance.

The potential difference developed across the resistance is amplified by vacuum tube circuits and is made to operate a mechanical counter. In this way single particles can be registered.

2.2. Voltage Characteristic of the G. M. counter

Furthermore, in a detection system, the voltage characteristic of the counter in Figure (1) is required to be considered when setting up the detection system so that which voltage range is optimum in our detection system. That optimum voltage range can give the reliable results of the counting system that is not directly proportional to the applied EHT. It is seen that there is a threshold below which the tube does not work in the voltage characteristic curve.

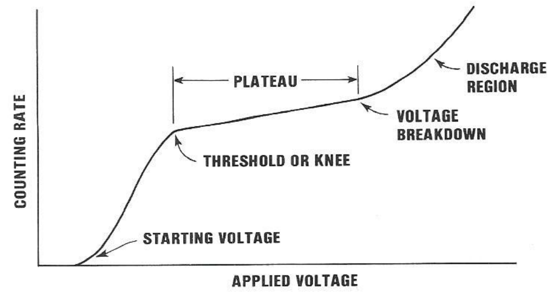

Figure 1. Typical Geiger-Muller Characteristic Curve

This can be several hundred volts. As the applied potential is increased, the counting begins and rises rapidly to a flat portion of the curve called the plateau. This is the region of the counter operation where the counting rate is, more or less, independent of small changes in potential difference across the tube. Beyond the plateau the applied electric field is so high that a continuous discharge takes place in the tube and the count rate increases very rapidly. It does not require any event for any ionizing event for this to happen so that the tube must not be used in this region. Though the operating voltage range for this type of counter is 300 to 1000 volts, the optimum voltage of 800 V has been taken for our detection system to operate the counter properly.

Using the GM counter has some advantages and disadvantages: it is insensitive for a period of 200 to 400 μs following each pulse, which prevents its use at very high counting rates. It cannot provide information about the particle or photon causing a pulse; the GM tube does not differentiate between kinds of particles or energies; it simply gives an output pulse when any ionizing particle triggers this avalanche. These output pulses are then recorded in a scalar which acts as an electronic adding machine.

In this research work, the GM counter we used here to count the beta particles has the follow features; the dimension of 12 x 12 x 5 Inch (Approx.) and a weight of 8 kg (Approx.), a 6 digit display and the preset time limit of 1-99.9 sec, and the specification for operating voltage of 300-1000 volts.

2.3. Radioactive βsource

Radioactive sources are used for a wide variety of peaceful purposes in industry, medicine, agriculture, research and education; and they are also used in military applications. A radioactive source or radiation source is a sample of a radionuclide, and emits ionizing radiation (one or more of gamma rays, alpha particles, beta particles, and neutron radiation). Generally, sources are used for irradiation, where the radiation performs a significant ionizing function on a target material, or as a metrology calibration source, which is used for the calibration of radiometric process and radiation protection instrumentation. There are different kinds of radioactive sources that are artificially created or naturally occurred. They may be radioactive materials around nuclear reactors, nuclear fuel, fall-out and other standard sources, which are intended to perform experiments in research areas. They may produce either of the rays; alpha, beta, gamma, neutron or fission fragments. The International Basic Safety Standards provide an internationally harmonized basis for ensuring the safe and secure use of sources of ionizing radiation.

In this research paper, the calibrated source of ^{60}Co (-41kBq) has been used to count the number of particles entering the counter as shown in Figure (2) and Figure (3).thermal conductivity k=0.033-0.024 W/m-K (thermal conductivity). Outer casing is usually high-density polyethylene (HDPE). Production of pre-insulated pipes for district heating is regulated by the standard EN253. According to EN253:2003, pipes must be produced to work at constant temperature of 130 °C (266 °F) for 30 years, keeping thermal conductivity less than or equal to 0.033 W/m-K. There are three insulation thickness levels.

Insulated pipelines are usually assembled from pipes of 6 meters (20 ft), 12 meters (39 ft), or 16 meters (52 ft) in length, laid underground in depth 0.4–1.0 meter (1 ft 4 in–3 ft 3 in). Efficient working life of district heating pipelines networks is estimated at 25–30 years, after which they need to be replaced with new pipes.

Figure 2.Over-view of the ^{60}Co source

Figure 3. Rear-view of the ^{60}Co source

III. EXPERIMETAL METHOD

Before taking up the radiation measurement with G. M. counter, the following precautions must be known. Important Precautions for Using G.M. Tube are;

(1) Handle the G. M. Tube with extreme care
(2) Hold it in the middle of the body
(3) Do not touch the end window with finger
(4) Mount the detector carefully in the circular ring adaptor and place it in the G. M. Tube
(5) Connect the G. M. Detector leads with proper polarities. The central anode pin to RED. (+) Banana plug and cathode wire lead to Black.(-) Banana plug. Reverse connection if done will damage the tube.
(6) Do not touch the tube, when in operation.
(7) Always keep the G. M. Detector in the stand only. When we are not using for experiments keep it in a separate place along

with G. M. Stand by disconnecting the cable.

(8) When we switch ON and OFF G. M. Counting system ensure EHT dial to be at minimum position.

(9) Do not drop it or give jerks.

Since the G. M. counter is a gas filled counter, it depends on ionization process to obtain the voltage pulse that will be registered or output as a count in the scalar. Though the operating voltage range for this type of counter is 300 to 1000 volts, the optimum voltage of 800 V has been taken for our detection system to operate the counter properly.

In our detection system, the radioactive beta source of ^{60}Co and the G. M. counter are used to obtain the number of particles or counts every 60 second. So, the number of counts for each minute is obtained with increment of distance. Firstly, the background counts are measured five times every 60 second and then the average count is taken. The background counts are measured five times because it is better to take more times while taking up the background counts. The gross counts are measured with different absorber thickness of 0mm, 0.05mm, and 0.1mm up to 0.30mm with the increment of 0.05mm. The experimental set up is shown in Figure (4). After subtracting the average background count from each gross count, the respective net counts or true counts are finally obtained as shown in following equation,

$$N = G - B$$

where, N = Net count

G = Gross count

B = Background count

Figure 4. Experimental set up of a Geiger Muller counter

IV. RESULTS AND DISCUSSION

The background counts are needed to be measured at first because the radiation dusts from the source may be present in the stand if the gross counts were measured previously. The background counts are shown in Table (1). The background counts are taken five times because it is better to take more times while taking up the background counts. It is needed to subtract the background counts from the gross counts because the radiation from the source cannot be obtained separately. It is always accompanied by the background radiation. These radiations may be the cosmic rays from the sun, the radiation from naturally occurring radioactive sources in the earth, the radiation from the radiated materials around our detection system and so on. The net counts are described in Table (2).

Table1. Background Counts of the Detection System

Sr	Counting time(s)	Background count(B)
1	60	19
2	60	19
3	60	12
4	60	18
5	60	22
Average background count		18

Table 2. Net Counts of the Detection System with Different Thickness of Al

Sr	Thickness of Al(mm)	Observed Count(G)	Net Count(N)
1	0	477	459
2	0.05	332	314
3	0.1	245	227
4	0.15	215	197
5	0.2	195	177
6	0.25	184	166
7	0.3	181	163

V. CONCLUSION

The number of beta particles entering the GM tube is gradually decreased because of increasing the absorber thickness between the radioactive beta source and the detector window in Figure (5). The number of counts is at maximum without the absorber. This means that the beta particles travel through the air with no difficulty. When the absorber of thickness 0.05 mm is placed between the source and the detector, one fourth of the number of particles is decreased obviously. As soon as the absorber thickness is 0.1 mm, only half of the particles can enter the G. M. counter. As a conclusion, since the beta particle can go through the air a few millimeters, we can prevent it with a few millimeters of aluminum foil. To avoid the radiation hazards and damages while going around the radiated areas and radioactive materials, it can be easily understood that we need a proper protection against the different types of radiation and as far as possible from these areas and sources. Beyond this research paper, we can also study that the radiation behaves as an inverse square law like Coulomb's law and Newton's gravitational law. As a further study, the attenuation coefficients of the materials, the determination of the half-life of the radioactive source and other nuclear properties associated with the counting system can be studied.

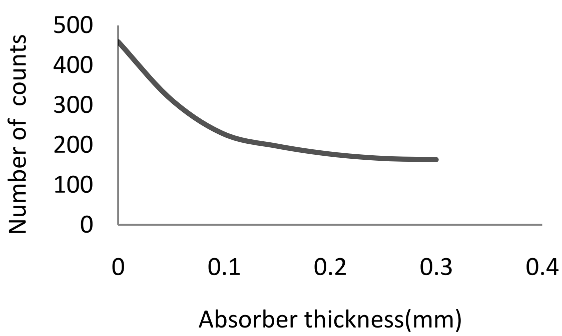

Figure (5) Variation of the Number of Particles Entering the Detector with Different Thickness of Absorber

REFERENCES

[1] N. Tsoulfanidis, Measurement and Detection of Radiation, Second edition (2012)