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Study of the Buildup Factor of Gamma Ray of Polymer And Nanoparticle-Tungsten Oxide Composite For Shielding Application

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Abstract: In this research, the buildup factor for gamma ray of Polymer And Nanoparticle-Tungsten Oxide Composite form (epoxy)- as a base material with nano-tungsten oxide (WO3) powder as (reinforcement materials) for shields prepared with different concentrations (10%,20%,30%,40%) as reinforcement materials with different thickness ranged 1 to 5 cm has been studied the effect of increasing the concentration of (WO3) .As well as the effect of increasing the thickness of the shield used with increasing the concentration of each thickness . The radiation source of gamma ray was Cs-137 which have (activity 9.49 µci and energy of 662 Kev) were used in measurement , the Sodium iodide doped thallium detector NaI(Tl) was used with (2"x2") for ORTEC program (Scintivision-Buffer) with an integrated measuring system have been used as electronic system . The results show that the buildup factor values decreased with the increased of concentration of nano particle-tungsten oxides and increased with increased the thickness of the prepared composite.

Keywords: The Buildup factor, Gamma ray, Composite materials.

1 Introduction

In the last years, there are many materials composite for Radiation shielding are considered to Protect from radiation risks from a high intensity radiation source by reduce and attenuation its intensity, The design of such shields depends on the type and energy of the ionizing radiation as well as the characteristics of the shield materials, gamma rays have high transmission during the material. The ray's transmission of the shield is of two types: interactive rays and other rays without interactive. The ratio of the total number of gamma photons emitted from the source at some point to Un scattered (or non- interactive). The penetrative of rays through the shield at the same point knows Buildup factor and which play an important of this factor and its role in the process of shield and protection against radiation. The buildup factor is used as a correction factor in the calculations of the appropriate thickness for the radioactive sources of gamma ray [1] in this paper, the study of this important factor of gamma ray with considered new materials composite.

2 The Theoretical Part

The attenuation of gamma radiation (absorption and scattering) inside the material can be studied by measuring the change in the intensity of the radiation (Good Geometry) with the change in the thickness of the material and calculate the rate of gamma ray force from the barrier or shield of the law of Beer Lambert

$$I = I_0 \, e^{-\mu * x} \quad \ldots 1$$

Where I_0 and I represents the incident and transmitted rays intensity respectively, μ is the attenuation coefficient and x is the thickness shield in cm.

This equation is valid when two basic conditions are available:

Firstly, the photon beam is very narrow, parallel and unique energy. Secondly, the thickness of the attenuation material shall be very low.

There is a specific range of ray in the material, depend on mean free path (mfp) which is the mean distance before absorption, which is denoted by Mean Free Path: [2] The

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rate of free path within the material is calculated before it is absorbed by radiation as following

$$\lambda = \frac{\int_0^\infty x \exp\left(-\mu * x\right) dx}{\int_0^\infty exp\left(-\mu * x\right) dx} \quad ...2$$

This term is used as an appropriate unit in the study of the transmission of photons in the material, in this regard some variables are known as the Buildup factor.

In all cases where the photon beam is wide or un parallel, or the thickness of the shield is relatively large (and this is the working condition in almost all cases), the previous relationship becomes unfit for application because of what Buildup factor defines resulting from the Buildup of photons at the Certain point Figure (1) shows the concept of the Buildup [3]:

The buildup factor results from two unique patterns coming from Photon interaction patterns with matter are Compton scattering and pair production, resulting for Compton scattering, some photons emitted from the source are in a far-off direction from the target which have scattering on the shield moves toward the target, increasing the number of photons reach to it (photon 1) Moreover, when a shield is thicker, it can occur for one photon rather than a continuous scattering of Compton scattering, which known as multiple scattering (photon 2) . In the pair production the energy may not be fully transmitted to the shield material. due to the fact that one of the photons produced by the annihilation of positron's with an electron of matter electrons may reach the target increasing the number of photons reached to it (photon 3), so the transmission rays from the shield are of two types, the scattering ray from (the Compton scattering and pair production),unscattering rays, Figure (2) shown these scattering and un scattering rays.

As a result, the scattering and unscattering rays. That interacted with the medium and scattering in different

Directions, will result in an increase in the intensity of the detector's total beam, This increase is a process of buildup of radiation "filtered through the designated medium called the buildup factor As in the following relationship

$$B = \frac{The\ total\ intensitybeam\ (I_t)}{The\ unscattering\ intensitybeam\ (I_u)} \quad …3$$

Or

$$I_t = BI_u \quad …4$$

For the narrow beam and the depend on equation (1) we get

$$I_{u.n} = I_{o.n} e^{-\mu * x} \quad …5$$

Where: ($I_{u.n}$) the intensity beam outside from the shield (narrow beam), ($I_{o.n}$)The incident intensity beam (narrow beam).

And for the wide beam, the equation (1) can be written in the following form:

$$I_{t.b} = BI_{o.b} e^{-\mu * x} \quad …6$$

Where: ($I_{t.b}$) the intensity beam outside from the shield (wide beam),($I_{o.b}$)The incident intensity beam (wide beam).

$$B = \frac{\frac{I_{t.b}}{I_{o.b}}}{\frac{I_{u.n}}{I_{o.n}}} \quad …7$$

3 Experimental parts

Nano tungsten oxide (wo3) powder has been used as a reinforcement with different concentrations of (10%,20%,30%,40%) and was mixed with The epoxy (C18H24O3) used as a base materials and composite to use as a shielding for gamma rays with different thickness ranged 1 to 5 cm.

And mixed well by a mechanical fan then transfer the mixture to the ultrasonic device to complete the mixing process during this device and a time period of about 20 minutes to get the best mix free of gaps and dislocations to be a mixture well mixed and then transfer the mixture to a mold dedicated to pour and then leave the mixture in the mold and at room temperature In an isolated place to dry well so that the shield produced by this mixture has a very high hardness and also light.

The templates were manufactured in vollume 60Cm^3, to be fit to the aperture of the used Collimators in the good geometrical arrangement and be suitable for the area of the used Sodium iodide doped thallium NaI(Tl) detector. the amount of epoxy and the nano-tungsten oxide powder is taken and weighed with a sensitive balance of measurement accuracy of of five digit of 0.00001.

4 Geometric Arrangement of Experiments.

For the purpose of studying the buildup factor of manufactured shields, the used collimators made from lead to obtain the good geometrical arrangement illustrates in the figure (3 a, 4 a) the purpose of collimators is to obtain a collimated beam then without the collimators lead to obtain the bad geometrical arrangement which shown in the figure

(3 b,4 b) when the geometry is organized, and used equation (7) was to calculate the buildup factor.

Table1. Shows the values of the buildup factor for different concentrations and different thickness.

	$I_{u.n}$	$I_{t.b}$	$\frac{I_{u.n}}{I_{o.n}}$	$\frac{I_{t.b}}{I_{o.b}}$	*B.F*
Com p.1	685	5064	0.9206	0.9300	1.010210
	672	4961	0.9032	0.9111	1.008746
	661	4878	.08884	0.8958	1.008329
	649	4788	0.8723	0.8793	1.008024
Com p.2	590	4625	0.7930	0.8494	1.071122
	570	4442	0.7661	0.8157	1.064743
	554	4288	0.7446	0.7875	1.057614
	536	4138	0.7203	0.7599	1.054830
Com p.3	510	4079	0.6854	0.7491	1.092938
	491	3905	0.6599	0.7171	1.086679
	480	3804	0.6451	0.6986	1.082932
	450	3556	0.6048	0.6530	1.079695
Com p.4	430	3536	0.5779	0.6494	1.123723
	415	3372	0.5577	0.6192	1.110274
	390	3152	0.5241	0.5788	1.104369
	369	2964	0.4959	0.5443	1.097600
Com p.5	320	2877	0.4301	0.5283	1.228318
	308	2732	0.4139	0.5017	1.212128
	278	2452	0.3736	0.4503	1.198813
	255	2212	0.3427	0.4062	1.185293

5 Results and Discussion

The buildup factor for each shield used was calculated and stated as shown in Table (1). In additions the relationship between the buildup factor as a function of concentration was determined and draw as shown in Fig (5) Which means that the sample of high-concentration polymer and low-concentration of nano-tungsten oxide powder is that the value of the buildup factor takes the highest possible value after That the buildup factor decrease by increasing the reinforcement material , The decrease of the buildup factor with the increased concentration of the nano-tungsten oxide can be attributed to the change of the polymer properties so that the composite material is good choose to use as attenuation materials for the gamma rays In general, the values of the buildup factor decrease by increasing the concentration of the powder because the properties of the composite material are directed towards the properties of the reinforcement material. As is known, the metal absorption of the radiation is higher than the polymer [5,6] In order to reach the desired and optimized concentration to attenuation the gamma rays with the knowledge that the polymer alone is not suitable to use it as a shield and the best concentrations is (40-60)so the suggestion materials composite consider promising candidate for this purpose.

Figure (6) represents the buildup factor as a function of the shield thickness ranging from 1 cm to 5 cm and different concentrations of nano- tungsten oxide powder. an increase in the buildup factor by increasing the thickness used and is a realistic result of the buildup factor. This result is a good assurance of the suitability and suitability of the composite materials with the sample thickness used as shields against radiation because they give a similar result to the act of buildup factor of the solid material when changing thickness. This is due to the increase in the cross-section of the interaction, ie, the increase in probability of small-angling when thickness increase and Table 1 shows the values of the buildup factor for different thickness [7, 8].

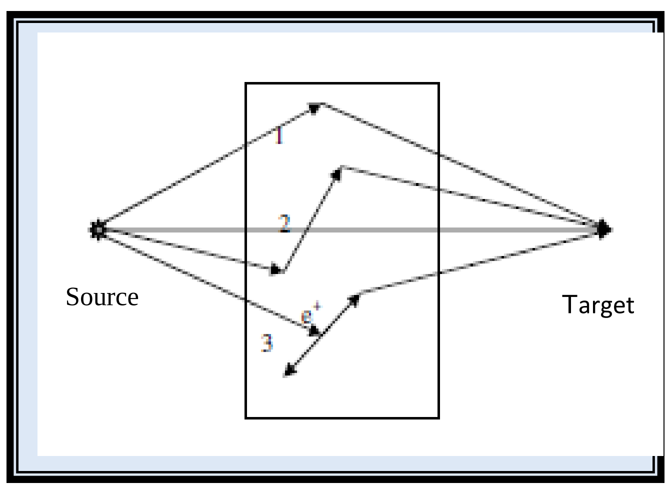

Figure 1. the buildup factor concept [4]

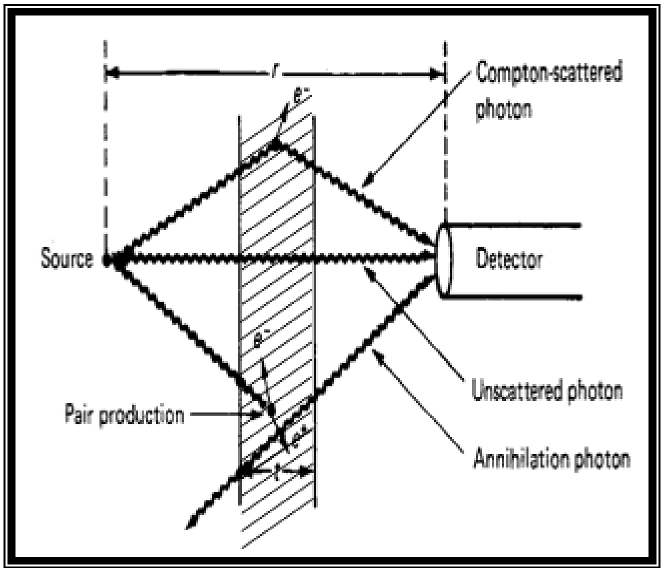

Figure 2 .the scattering and unscattering rays [4]

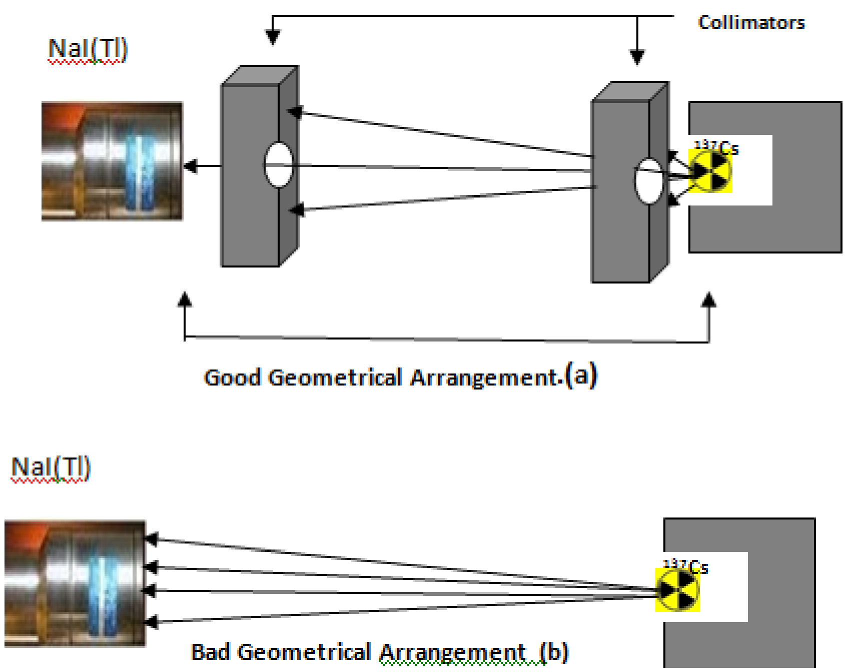

Figure 3. Geometric Arrangement of zero reading

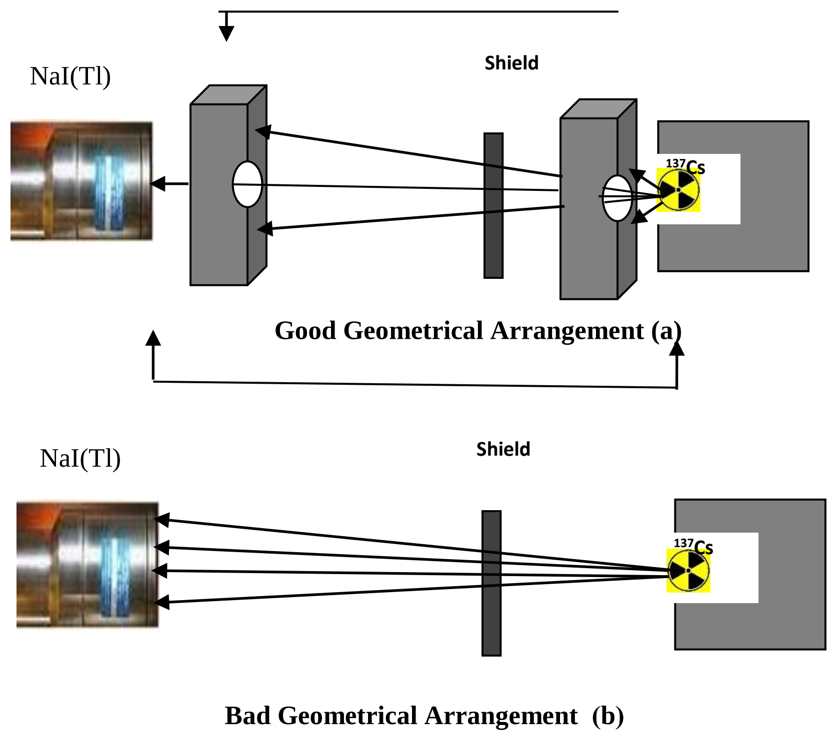

Figure 4. Good and Bad Geometric Arrangement of experiments.

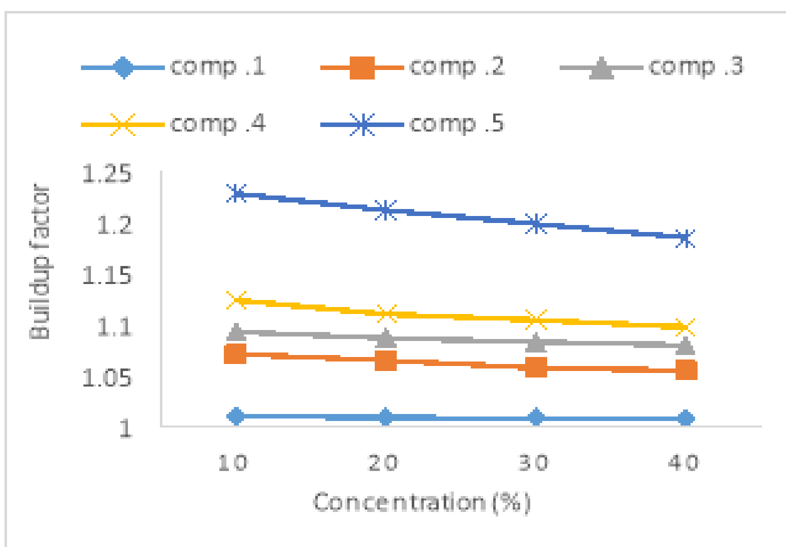

Figure 5. Relationship between the buildup factor and different on cent rations of the composite material

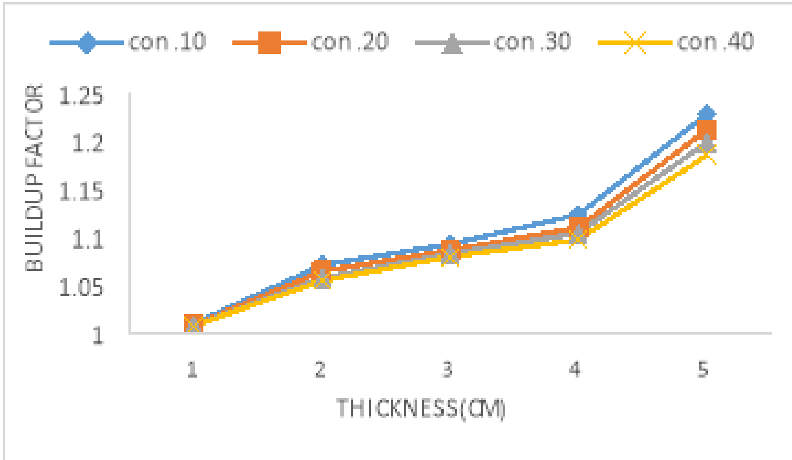

Figure 6. Relationship between the buildup factor and different thickness of the composite material

6 Conclusions

In this work, some remarks have been concluded such as the new and promising composite materials (polymer + metal), can be substitute lead and heavy materials used in attenuation rays and shields with lighter and less expensive materials. In addition, the study of the buildup factor as a function of reinforcement concentration and shield thickness.

The decrease of the buildup factor with the increased concentration of the nano-tungsten oxide. as well as The increase in the buildup factor by increasing the thickness of the shield.

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