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Fabrication and Radiocharacterization of Boron Carbide and Tungsten Incorporated Rubber Shields

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ABSTRACT: Radioactive ray safeguard is a physical impediment which is placed between radioactive source and the protected object in order to decrease the amount of rays' radiation in the protected area. Different materials such as lead, iron, graphite, water, poly ethylene, concrete, or rubber can be used for protection against nuclear radiations. In safeguard's common designing, two types of Gama and Neutron radiations are usually considered. The weakening amount of Gama radiations is proportional to the mass and atomic number of the safeguard's material. Covering Neutron source varies with regard to the source power and its application. However, what is always true is having the least dose with the least dimensions outside the safeguard. The dose of the safeguard's outside partition is resulted from quick, slow and thermal neutrons, and also from the source's Gammas and secondary Gammas. Neutrons use retarding and neutron-absorbing materials in order to reduce the dose. Due to the weak mechanical characteristics of the pure elastic composites, fillers are used to strengthen and improve their characteristics. Strengthening the elastic material is often defined through increasing the characteristics such as hardness, module, refraction energy, solidity, tear resistance, tensile solidity, lassitude resistance, abrasion resistance. In this paper, rubber shielding materials with boron carbide and tungsten as impurities have been fabricated. The optimum boron carbide contents (5% weight percent) have been evaluated using the Monte Carlo code, MCNP. The gamma attenuation coefficients for different boron carbide and tungsten contents have been measured for a number of rubber shields with dimensions of $1 \times 9 \times 16 cm^3$.

KEYWORDS: Rubber Shielding, Boron Carbide, Tungsten, Gamma Attenuation, MCNP.

1 INTRODUCTION

Radioactive ray safeguard is a physical impediment which is placed between radioactive source and the protected object in order to decrease the amount of rays' radiation in the protected area. Different materials such as lead, iron, graphite, water, poly ethylene, concrete, or rubber can be used for protection against nuclear radiations. In safeguard's common designing, two types of Gama and Neutron radiations are usually considered. The weakening amount of Gama radiations is proportional to the mass and atomic number of the safeguard's material. Among the effective materials in absorbing the Gama ray are lead, steel, tin, bismuth, iron and tungsten [7]. Tungsten is not a toxic material and in terms of weakening power is better than lead and unlike it, can easily be mixed with polymeric materials. So, it is possible to make flexible safeguards that have great applicability in protecting rays by using composite materials with polymer and tungsten base [6]. Covering Neutron source varies with regard to the source power and its application. However, what is always true is having the least dose with the least dimensions outside the safeguard. The dose of the safeguard's outside partition is resulted from quick, slow and thermal neutrons, and also from the source's Gammas and secondary Gammas. Neutrons use retarding and neutron-absorbing materials in order to reduce the dose [8]. Some examples of retarding materials are: water, poly ethylene, paraffin, and other hydric materials. Among neutron-absorbing materials which have high area for absorbing hot neutron are cadmium, boron, and lithium which in case of mixing with polymers besides reducing the hot neutron's dose outside the safeguard, can decrease the possibility of interactions like H(n,γ)D and generation of secondary high-energetic Gama within the safeguard. These compound safeguards can be applied in coverage of neutron's source like radio-isotopic source of 241Am-Be, and in analyzing materials through making use of instant Gama (PGNAA). In PGNAA method, neutron's radiation to the sample and spectroscopy of Gammas resulting from neutron's interaction with the core of targeted elements happen simultaneously. Therefore, any gamma which has a base other than the targeted material is considered as the base Gama and the obtrusive factor [3].

2 EXPERIMENTAL STUDY

Due to the weak mechanical characteristics of the pure elastic composites, fillers are used to strengthen and improve their characteristics. Strengthening the elastic material is often defined through increasing the characteristics such as hardness, module, refraction energy, solidity, tear resistance, tensile solidity, lassitude resistance, abrasion resistance. Practically, strengthening is the improvement in the work life of the elastic pieces [9]. After Vvlkansh phenomenon, strengthening phenomenon in the elastomers, especially elastomers with general usage, is the most important process of strengthening the mechanical characteristics. The effect of common strengthening fillers like soot on the composite is as follows: generally by the increase of the amount of soot, module, tensile solidity, and hardness will increase and the length will decrease. By increase of reactive fillers even in the small amount, module, tensile solidity and length will increase simultaneously which is a feature of reactive fillers. The main purpose of adding different fillers to the elastic composite is to improve its special characteristics and to decrease the final cost of the product [10]. Among all the fillers, soot has fully been known as the effective strengthening filler for rubbers and elastic composites. However, adding soot to the composite gives black color to the piece. Because of that, researchers in two recent centuries have focused on other strengthening elements to replace soot [11]. In order to simulate the characteristics of boronic poly ethylene to find the proper percent of boron carbide in the composite a geometry like that of figure 1 was used. To investigate the effect of designed safeguards against neutrons, am-Be neutron source with energy spectrum ranged 100 keV – 11/3 MeV was used. The one-way plate source radiates with the area of 50 cubic centimeters and in the negative direction of the Y-axis and the area of this source is in a way that covers all the surface of the safeguard [2], [4].

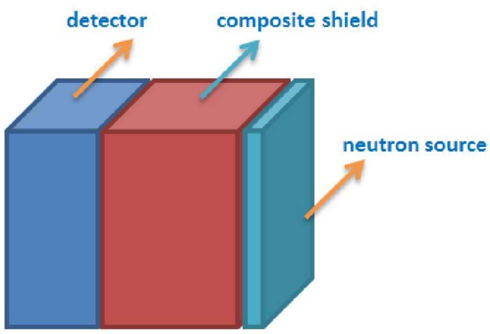

Fig. 1. Simulation geometry in order to find the optimal amount of boron in the safeguard [12]

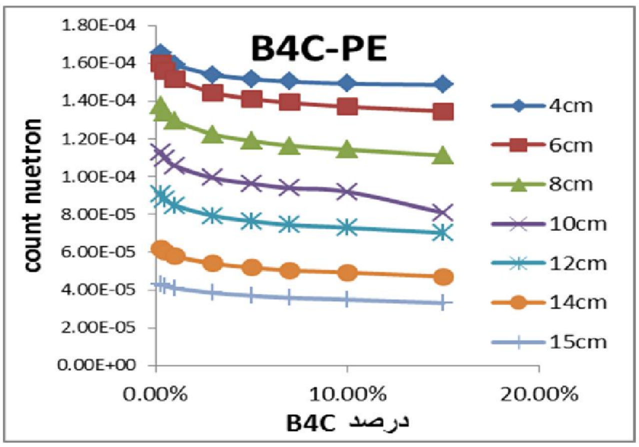

Fig. 2. Neutron's count changes due to adding boron to the safeguard's different thicknesses [19]

As can be seen in figure 2, by increasing the percent of particles, the number of neutrons will decrease up to 5 percent and after that it follows almost a fixed procedure. It can be concluded that the maximum of strengthening material to be used in making the composite is 5 percent [18]. Of course, by increasing the thickness of composites, the number of neutrons will be decreased and it should be considered in the measurements. With regard to the previous studies, most of the composite safeguards are from polymeric materials and have boron or lithium compounds. When using boronic composite safeguards, in addition to hydrogen energy peak of 2.2 MeV, the peak of 478 KeV related to boron appears with the intensity of about 2500 times in comparison with the reaction of neutron with hydrogen. But the positive point is the more weakening of the 478 KeV Gama in heavy elements like tungsten and bismuth. In the present study, in order to prepare the proper safeguard for weakening the flux of neutron, boron-carbide was used which based on the previous simulation study by MCNPX code, by having 5 percent of B4C with micro dimensions would include the best index for weakening the neutron. Also, tungsten was identified the best for protection against Gama [6]. Besides, elastic composites composed of 5 % boron carbide with 5 % tungsten, 5 % boron carbide with 15 % tungsten, and 5 % boron carbide with 30 % tungsten were made for the purpose of comparison. In this research, NR/CR compounds have been used to make elastic safeguards. Also, other required materials for preparing usual rubber are as follows: The materials of first group are considered as the polymer's bases which have multiple links with each other [2]. These two combinations have been used so that the sample is resistant against Ozone's conditions and has high mechanical characteristics as well as high capacity for accepting fillers. The materials of second group are cure systems which after weighing are put in a dish. The materials of third group are fillers which include soot and oil. Composites were prepared by the laboratory two-roll mill with the speed of 50 rpm and in the mixing temperature of 30-40 degrees of centigrade. After softening the rubber CR and NR on the roll for 5 minutes, the activator and catalyzer elements and at the end, the sulphuric cooking element were added to the compound. After the final mixture on the roll for 20 minutes, first 5 % boron carbide powder was mixed with the compound on the roll and at the final stage the tungsten powder with 5, 15, and 30 percent was added to the elastic compound. The plates were prepared by the hot press in the 19 degrees of centigrade and under the pressure of 25 mega Pascal in the form of pressurized molding. From each sample, two safeguards were cut in the dimensions of 16*9*1. The examples of the made rubbers are presented in figure 3. In order to measure the reduction of Gamma's flux, cesium 137 plate source along with NAI collimator and detector were applied [5].

Fig. 3. Three examples of elastic safeguard made with boron carbide and tungsten impurity

3 Results

In this research, for the first time in Iran, by using hard phase of boron carbide and moving toward making flexible plates, safeguards have been designed and made which are very light, and resistant against Ozone's demolition, have high resistance against heat, and by including different amounts of neutron-absorbing materials like boron and lithium have a very good weakening index for absorbing hot neutrons. The plate composites are easily used and with no need for expertise can be cut by simple tools like scissors and cutter [11].

Table 1. The amount of reduction of Gama's flux in three Samples of Safeguard

sample	Sample thickness(Cm)	reduction in gamma flux(Percent)
first sample	1	11%
	2	20%
Second sample	1	14%
	2	24%
third sample	1	18%
	2	30%

4 CONCLUSION

They can also be installed on the wall, around the oval tanks, and other forms according to user's need. Composite safeguards can be used in all the operations which contain radioactive substance. In table 1, the amount of reduction in cesium 137 source's Gama flux is presented by the help of NAI detector by putting the three safeguard samples with thickness of 1 and 2 centimeters [12]. According to the spectroscopy illustrated in the table 1, by the increase of tungsten in the samples, the amount of reduction in the Gama's flux will increase. That is, the increase of tungsten in the samples has direct relation with decrease of flux. Also, by the increase of safeguard's thickness in each sample, the amount of Gama's flux between source and detector will decrease [5], [1].

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REFERENCES

[1] K., Heydari, N., and S. Ashrafi, "Management of agricultural water consumption, drought, and supply of water for future demand in Iran," Proceed*ings of 7th Int'l Conference on Sustainable Development and Management of Dry-lands in 21 century*, 2003.

[2] United Nations, *The Demand for water: Procedures and methodologies for projecting water demands in the context of regional national planning*, Nat. Resource, Water Ser. 3, United Nations Publications, New York, 2007.

[3] World Energy Council (WEC), *Energy Efficiency Policies around the World: Review and Evaluation Executive Summary*, A Report by the Word Energy Council, London, United Kingdom, 2008.

[4] Interlined M.A., et al., *Integrated Evaluation of Energy Conservation*, National Report for the Netherlands, Energy Research Center of the Netherlands, 1999.

[5] Anderson J., "The environmental benefits of water recycling and reuse," *Water Science and Technology*, 2006.

[6] Metcalf & Eddy, *Water Reuse, Issues, Technology and Application*, McGraw-Hill, 2007.

[7] Herbert Son, P.W. and E.L. Tate, "Tools for water use and demand management in South Africa, World Meteorological Organization," *Technical Reports in Hydrology and Water Resources*, 2007.

[8] Aprsht, W, "identification of structural materials in nuclear technology," *refugees, H, printing, Tehran, Tehran University Institute for Publishing and Print*, 2009.

[9] ACI Committee 211, *Standard Practice for Selecting Proportions for Normal, Heavy weight, and Mass Concrete*, Appendix (4), American Concrete Institute, 2002.

[10] ACI Committee 304*, Heavyweight concrete, Measuring, Mixing, transporting, and, Placing (ACI 304.3R-96)*, Detroit, American Concrete Institute,1996.

[11] American Society for Testing and Materials, *Annual Book of ASTh Standards, Significance of tests and properties of concrete an concrete making materials,* United States, ASTM special Technical Publication, Vol. 04.01, 04.02, 2007.

[12] Bashter, I. I., "Calculation of radiation attenuation coefficients for shielding concretes," *Annals of Nuclear Energy*, Volume 24, Issue 17, pp. 1389-1401, 1997.