INVESTIGATION ON THE EFFECTS OF TITANIUM DIBORİDE PARTICLE SIZE ON RADIATION SHIELDING PROPERTIES OF TITANIUM DIBORIDE REINFORCED BORON CARBIDE-SILICON CARBIDE COMPOSITES

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ABSTRACT

Composite materials have wide application areas in industry. Boron Carbide is an important material for nuclear technology. Silicon carbide is a candidate material in the first wall and blankets of fusion power plants. Titanium diboride reinforced boron carbide-silicon carbide composites which were produced from different titanium diboride particle sizes and ratios were studied for searching of the behaviour against the gamma ray. Cs-137 gamma radioisotope was used as gamma source in the experiments which has a single gamma-peak at 0.662 MeV. Gamma transmission technique was used for the measurements. The effects of titanium diboride particle size on radiation attenuation of titanium diboride reinforced boron carbide-silicon carbide composites were evaluated in related with gamma transmission and the results of the experiments were interpreted and compared with each other.

Key words: Nanocomposite, Boron Carbide, Titanium Diboride, Silicon Carbide, Cs-137 Gamma Source, Gamma Transmission Technique

INTRODUCTION

Boron carbide has wide application areas in industry. Some of these areas are nuclear technology, military industry, ceramic industry and air-space industry [1, 2]. Boron carbide has some important properties such as low-density, high hardness and corosion resistance, chemical stability and high neutron capture feature [2]. Some boron carbide application fields are lightweight ceramic armor, sand blasting nozzles, nuclear reactors, reactor control rods and the radiation shielding materials [2, 3]. However, boron carbide is brittle, has low strength and high temperature sintering properties [3, 4]. Sintering of pure boron carbide to high densities is difficult. So, specific additives such as SiC, TiB_2, AlF_3, elemental boron and carbon have been used as sintering aids to increase the density of composite [2-5]. Silicon carbide has been considered as a candidate material in the first wall and blankets of future fusion power plants because of its safety, environmental and economic benefits [6].

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In this study, titanium diboride reinforced boron carbide- silicon carbide composites which were produced from different titanium diboride particle sizes and ratios were studied for searching of the behaviour against the gamma ray. For the investigation of the gamma radiation behaviour of these materials, Cs-137 radioisotope was used as gamma source in the experiments. Cs-137 gamma radioisotop source has a single gamma-peak at 0.662 MeV and its half life is 30.1y [7, 8]. Gamma transmission technique was used for the measurements.

Different titanium diboride particle sizes and ratios in titanium diboride reinforced boron carbide-silicon carbide composites were evaluated in related with gamma transmission and the results of the experiments were interpreted and compared with each other. Therefore, the effects of boron carbide particle size in titanium diboride reinforced boron carbide-silicon carbide composites on gamma radiation attenuation were investigated against Cs-137 gamma radio-isotope source by using gamma transmission technique.

EXPERIMENTS AND MATERIALS

Gamma transmission technique is based on passing gamma rays through the materials. Detector and gamma source put both sides of the material. Detector material and gamma source are in the same axis. The gamma radiation counts are measured reaching to detector from the source. The counts with material and without material are compared and evaluate [7-9]. *Fig.1* shows schematic view of gamma transmission technique.

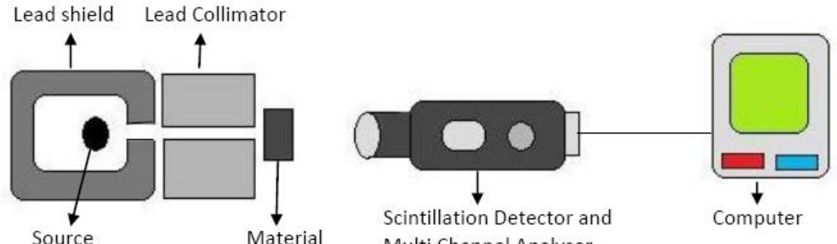

Fig. 1. Schematic View of Gamma Transmission Technique

The radiation passing through the material is calculated by the following equation: where I and I_0 are the transmitted and initial gamma ray intensities, respectively, μ is linear attenuation coefficient of material at specific γ- ray and x is the thickness of the material.

$$I = I_0 e^{-\mu x}$$

The materials which were used in the experiments have different boron carbide particle size ratios in the composites. Thus they are coded according to their boron carbide and titanium diboride ratios by volume in composites and particle size ratios. *Table 1* shows the materials that used in the experiments and their ratios by volume in the composite materials.

Table 2 shows the hardness, strength and density properties of the materials which were used in the experiments [5].

For production of nano scale titanium diboride, titanium diboride materials were milled in Spex 8000 mill for one hour with WC balls.

All composite materials were sintered at 2250 °C for 2 hours under 130 MPa pressure. Cs-137 Gamma Radiation source which has 8.9 μCi was used in the experiments. Lead blocks were used for radiation shielding and collimation. The collimator diameter is 7 mm. The distance between the detector and source is 10 cm.

Firstly background radiation measured. Then Cs-137 Gamma source was set. Initial intensity count (I_0) was measured. Then materials were set and intensity counts (I) were measured for different thickness values. All counts were measured three times for 600 seconds. Net counts calculated by reducing background value. Average values and standard deviations were calculated. For rational evaluating, relative intensity (I/I_0) values were calculated. Results were given with tables. Relative intensity-Material Thickness Graph was drawn for each Titanium diboride ratio and particle size. Exponential distribution was shown on graphs and exponential equations were calculated. Then results were evaluated and discussed.

RESULTS AND DISCUSSION

Results for 8202_b, 8202_k, 8204_b, 8204_k, titanium diboride reinforced boron carbide-silicon carbide composites at different thicknesses with Cs-137 Gamma source are given on table 3, table 4, table 5 and table 6.

Using the values on the tables Relative Intensity-Material Thickness Graphs were drawn for all titanium diboride reinforced boron carbide-silicon carbide composites. Exponential fitted equations were calculated. Figure 3 shows Relative Intensity-Material Thickness Graphs of all boron carbide-Titanium diboride composites.

Using the graphs on fig 3 the linear attenuations of the composite materials and correlation coefficients were calculated. The linear attenuation values and correlation coefficients of the composites are given on table 6.

The mass attenuation coefficients (μ/ρ) of the composite materials were calculated. The linear attenuation coefficients of milled titanium diboride reinforced boron carbide-silicon carbide composites are higher than unmilled reinforced ones.

CONCLUSIONS

It could be understood that for 8202_k the linear attenuation coefficient is higher than 8202_b. For 8204_k the linear attenuation coefficient is higher than

8204_b. The experimental values and theoretical values from XCOM are closed to each other.

In conclusion, 8202_k and 8204_k composite materials are more convenient than 8202_b and 8204_b for gamma radiation shielding in nuclear technology.

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