THE RADIATION SHIELDING PROPERTIES OF BORONIZED VANADIUM STEELS

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INTRODUCTION

The total linear attenuation coefficient μ (cm^{-1}), which is defined as the interaction probability of a photon in a media per unit path length [1], is the most remarkable parameter of radiation shielding. With the increasing use of radioisotopes in a variety of fields such as nuclear, industrial and medical enterprises, it became a more important parameter for solving problems in radiation dosimeter applications. As a result, it carried out a great interest to make researches on different shielding materials such as concretes [2-5], alloys and elements [6,7], and compounds [8,9]. All these researches showed that, materials with high density and atomic number, i.e. lead, steel or iron, are more suitable for gamma radiation shielding purposes.

Various types of stainless steel alloys are very common materials used in different fields, i.e. building construction, micro sciences, nuclear and medical facilities. This brings out the necessity of investigating its various properties. The stainless steel alloys contain high amount of iron and low amount of carbon elements [10]. By adding different elements or changing the element rates of the alloy, some other parameters of the material, besides its mechanical parameters, can be refined [11].

Vanadium (^{23}V) is one of the important by product elements which is exclusively used in non-ferrous and ferrous alloys due to its positive effects on fatigue resistance, hardness and high tensile strength of the alloy. Also, a wide range of applications with other alloy elements such as titanium, nickel, aluminum, chromium is possible[12].

These properties make stainless steel containing vanadium worth inspecting its shielding property against gamma rays. In a recent experimental study, boronizing effect on the photon shielding properties of some steel samples was carried out by Akkurt, et.al [13] and it was concluded that boronizing effected radiation shielding properties positively.

Being inspired from the mentioned study and considering that the literature is not rich about the subject, the photon attenuation coefficients of boronized vanadium steel was investigated.

MATERIALS AND METHODS

The vanadium steel samples were boronized in Süleyman Demirel University Technical Faculty laboratory [14]. The process was performed in a solid medium using the powder pack method and the commercial Ekabor-II boron source and activator (ferro-silicon) were mixtures were used. Then the packed steel samples were heated in an electrical furnace for several hours at about 1000 ^{o}K under atmospheric pressure. The samples were cooled at a rate of 288 °K/min to room temperature before removal from the chamber after the bonding process.

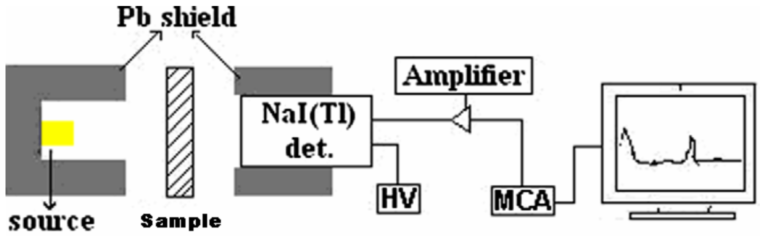

Figure 1. Experimental setup used in the measurement

Finally, the samples were sectioned from one side and prepared metallographic ally up to 1200-grid emery paper and polished, using 0.3-Am alumina pastes.

For the radiation shielding experiments, the linear attenuation coefficients were measured using 3’’x3’’ NaI(Tl) scintillator gamma spectrometer system, for which one can find detailed description [3,4] and displayed in Fig.1. Gamma rays were obtained from the ^{137}Cs (662 keV) and ^{60}Co (1172 and 1332 keV) energies. The total linear attenuation coefficients of vanadium steel samples were calculated by

$$\mu = (1/x)\ln(I_0/I) \tag{1}$$

formula where I_0 and I are the magnitudes of unattenuated and attenuated photon beams, and x is the material thickness, respectively. Genie2000 (v.3.0) spectrum processing software was used for calculating beam intensities. For comparing experimental values, theoretical μ values were calculated by means of mass attenuation coefficients, using XCOM code at 1 keV-100 GeV energy range [15]. For this purpose, chemical percentages of concrete constituents were entered to the program and linear attenuation coefficients were obtained.

RESULTS AND DISCUSSION

The linear attenuation coefficient μ (cm^{-1}) of steel have been obtained before and after boronizing. The results have been displayed in Fig.2 for 662, 1773 and 1332 keV photon energy. It can be seen from this figure that the linear attenuation coefficient μ (cm^{-1}) decreased with the increasing photon energy.

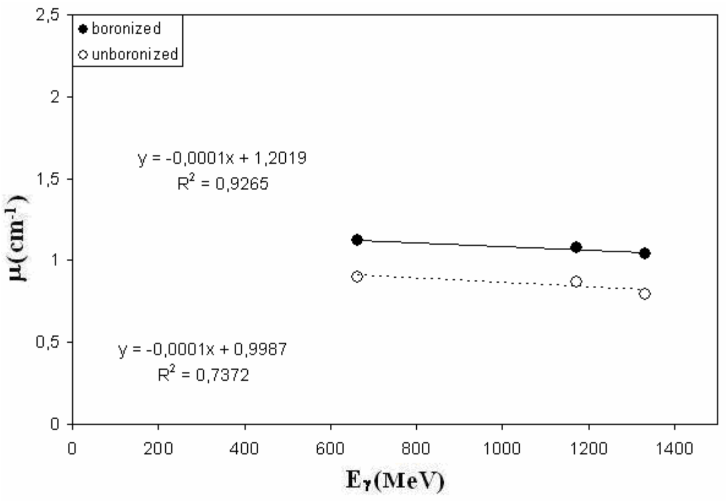

Figure 2. The obtained results for boronized and unboronized steel.

It can also clearly show that from this figure that the boronizing improved radiation shielding properties of the steel.

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