Boronizing: Radiation Shielding of Stainless Steel

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Abstract: Boron is an important element and about 75% of the world reserve is in Turkey and it can be used in a variety of 400 different fields. Moreover it can be used in strategic fields such as defense or nuclear technologies directly or by boronizing of materials for some different applications. In the radiation shielding besides some materials such as lead, the boronizing of the material can be used to increase radiation shielding capability. In this study the importance of the boron and its application will be detailed and application of the boronizing on the radiation shielding properties of some types of steel will be presented.

Keywords: Boron, radiation shielding, stainless steel

Introduction

Boron is a black, lustrous material and conducts electricity like a metal at high temperatures and is almost an insulator at low temperatures. It was first isolated in 1808 by heating boron oxide (B_2O_3) with potassium metal. The elemental boron is widely used to increase hardness in steel and also used in the nonferrous-metals industry, generally as a deoxidizer, in copper-base alloys and in aluminum castings to refine the grain. It is estimated that about 75% of the known boron reserves of the World are in Turkey. On the other hand the only 22% of the boron based production are produced in Turkey. The boron can be used in a variety of 400 different fields such as kitchen staff, defense sector and also agriculture. Radiation always exists in our environment due to the natural and man-made sources and this is called background radiation. Especially after development of the technology man-made radiation has significantly increased. Thus the radiation protection became an important subject in nuclear science. The basic rule for the radiation protections is time, distances and shielding and the latest one is a most commonly used methods. Although heavy metals such as lead have been used for this purpose, an alternative method would be investigated. Boron can be an alternative for radiation shielding and boronizing of the materials used in radiation shielding can be used to improve radiation shielding properties. In this study radiation shielding properties of the boronized steel has been investigated.

Materials and Methods

Besides utilization of boron itself, boronizing is the most commonly used technology in different fields. Boronizing processes is an important technology and different types of samples have being boronized in Suleyman Demirel University Technical Faculty laboratory for different purposes (Calık et al. 2007). This is achieved in a solid medium using the powder pack method where a commercial Ekabor-II boron source and activator (ferro-silicon) were mixed. The packed samples are heated in an electrical furnace for required period (usually several hours) at about 1000 ^{o}K under atmospheric pressure. After the bonding process the samples is cooled at a rate of 15 °C/min to room temperature before removal from the chamber. The samples are sectioned from one side and prepared metallographically up to 1200-grid emery paper and then polished, using 0.3-Am alumina pastes.

For the radiation shielding properties, the linear attenuation coefficients have been measured using gamma spectrometer system (Akkurt et al. 2004, Akkurt et al. 2006, Akkurt et al. 2008). In the system NaI(Tl) detector connected to Multi-Channel-Analyzer (MCA). Gamma rays have been obtained from the ^{137}Cs and ^{60}Co sources. Those produce 0.662 and 1.17, 1.332 MeV energy.

Results and Discussions

The linear attenuation coefficients (μ) of steel were measured at the photon energies of 0.66, 1.17 and 1.332 MeV obtained from ^{137}Cs and ^{60}Co γ-ray sources respectively. This measurement has been performed before and after boronizing. This is displayed in Figure 1 where it can clearly be seen that the boronizing processes increased linear attenuation coefficients.

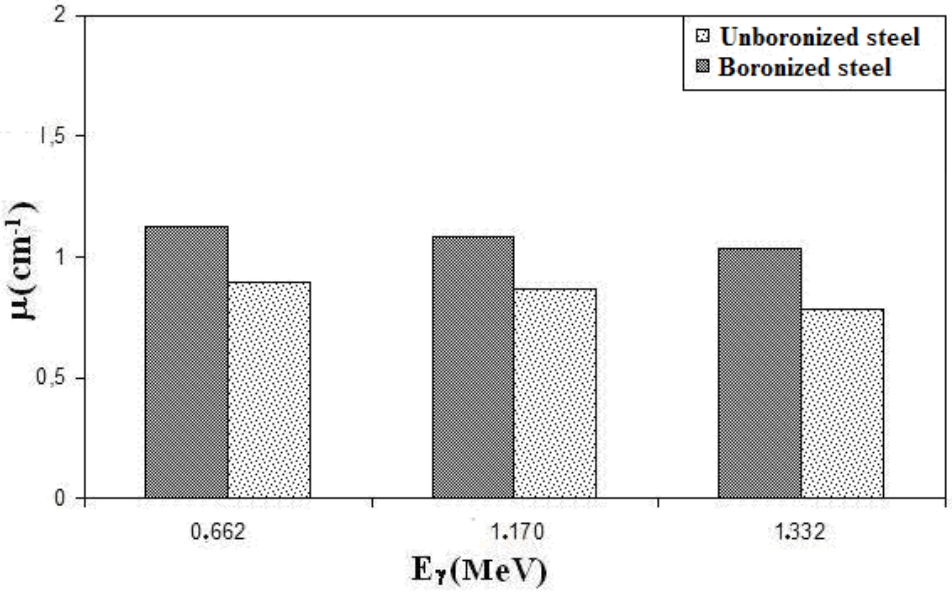

Figure 1. Linear attenuation coefficients for boronized and unboronized steel

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