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A "Sandwich" type of neutron shielding composite filled with boron carbide reinforced by carbon fiber

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HIGHLIGHTS

- Acetone–resin ultrasonic surface pretreatment of carbon fiber was firstly proposed.
- The boron carbide filler is helpful to improve the thermal stability of the CFRC.
- "Sandwich" type of neutron shielding composite material was firstly proposed.

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ABSTRACT

A "Sandwich" type of neutron shielding composite reinforced by carbon fiber was currently studied in view of the rapidly growing need of nuclear protective materials. Comparison to Scanning Electron Microscopy (SEM) analysis of a variety of carbon fiber surface treatment, a new technology, named acetone–resin ultrasonic pretreatment was better to ensure that the carbon fiber and the resin glue were solidified effectively by diffusion as a whole, and also worked out the traditional problem about full impregnation of carbon fiber. Meanwhile, differential scanning calorimetry (DSC) and thermogravimetic analysis (TGA) of the composite filled with boron carbide were observed. The conclusion was that the effect of the acid anhydride type curing agent (B-570) was better than the polyamide type (TY-203) in the field of heat resistance, and the carbon fiber was helpful to improve the thermal stability of the composite when the adding content was 28.2%. In addition, the "Sandwich" type of neutron shielding composite was prepared for the tensile performance test. Compared to the boron carbide particles added directly into the composite, it has a huge performance improvement in the mechanical properties when the content of boron carbide filled with 20%, meanwhile it significantly upgrade the neutron shielding performance with spraying with 0.4 mm.

1. Introduction

Recently, with the development of seeking for alternative new energy source, most of scientists focus on the field of nuclear energy [1]. It leads to a new topic about the security of the nuclear environment. The metal, non-metal materials and other protective carrier with ^{10}B can shield effectively for nuclear radiations. The traditional shielding way was mostly to use more thickly shield of lead plates, and cast reinforced concrete, etc., mainly by reducing the neutron speed and preventing the passage of neutron. However, the problem of making or moving the thick protective layers, the difficult to be repaired soon once it was destroyed, cannot meet the development needs of the nuclear power industry. So, the composites filled with ^{10}B have the advantage of convenient and safety in the nuclear environment, which is becoming the focus of the nuclear protection research [2–7].

Currently, most widely used nuclear protective materials are polyethylene plastic plates adding boron carbide, because of polyethylene containing a relatively high content of hydrogen atoms that is an effective neutron moderator by virtue of its scattering power, and boron carbide including some ^{10}B atoms that is also a good slow neutron absorber by means of huge thermal neutron absorbing cross section. However, the polyethylene plastic plates as a protective material also have its shortcomings of applied temperature be nearly 100 °C, which can only meet the requirement using at room temperature. For the need to apply in a higher temperature such as nuclear reactor, especially the event of radiation accidents, the polyethylene plastic plates may cause to be melted and lose the protective function [8].

In this regard, the carbon fiber reinforced composite materials show its excellent performance due to higher strength, lighter weight and better conductivity. And the plastic and resin

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