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A STUDY OF RADIATION RESISTANCE FOR DISKS OF NEUTRON CHOPPERS IN ESS

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Abstract

European Spallation Source (ESS) is designed as the world's most powerful neutron source, allowing to realize scientific breakthroughs in research concerning energy, materials, health and environment. Depending on the field of research, different neutron wavelengths from the full energy spectrum are required. The neutron chopper is a mechanical device that cuts out the required wavelength area from the entire neutron energy spectrum. One of the most important parts of the neutron chopper is the disc made of carbon fiber reinforced epoxy. During the operation of the chopper in the physical experiment, the disk will rotate at a high angular velocity in the conditions of high radiation fields. So, it follows that it is necessary to analyze the impact of radiation on the internal structure and mechanical properties of the chopper.

To investigate what kind of radiation damage occurs in different types of epoxies depending on the fluence, X-ray tomography together with the porosity analysis, three-point bending tests and the surface analysis have been carried out using scanning electron microscopy (SEM) for two different epoxies. Together, these studies provide the most complete picture of the resulting damages. Each type of epoxy has been irradiated with the following neutron fluences: 6,2·10^15 n/〖cm〗^2 ,8,9·10^15 n/〖cm〗^2 ,2,6·10^16 n/〖cm〗^2 which corresponds to the absorbed dose in water of 3 MGy, 10 MGy and 30 MGy.

X-ray tomography has been used to analyze microstructural damages after irradiation. It allowed to investigate the damages occurring not only on the surface of the sample, but also in its content. It has shown that the number of pores increases with the increasing dose. However, this effect was found only in one of the epoxies, which means that radiation damage is not universal for various types of epoxies.

Also, along with studies of mechanical properties using the three-point bending method, it was found that an increase in the number of medium-sized elliptical pores (40960 - 655360 μm3) enhances the maximum stress and Young's modulus of the material. Mechanism bringing together these two phenomena has not been established.

The next step in this project will be implementation of the neutron tomography and the subsequent data analysis. This will provide further information about the gas inside the pores, since X-rays and neutrons possess different cross sections.

A study of the orientation of pores on SEM will also be carried out. Are they directed along the fibers or perpendicular to them? Does their direction depend on the absorbed dose? Perhaps, the answers to these questions will help to understand the mechanisms of damage in the chopper material.

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