EFFICIENCY OF USING TITANIUM BORIDE AS A NEUTRON-ABSORBING COATIN[1]

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Safe storage of spent nuclear fuel (SNF) is actual now day problem of nuclear energetic. Today, nuclear power generates more than 10% of the world's electricity. The volume of accumulated SNF is more than 310 thousand tons. It makes necessity to undertake measures to increase the level of security during SNF storage and manipulations with them. One of the important factors that pose a radiation hazard during long-term storage and handling of spent nuclear fuel is the regeneration of part of the “unburned” fuel when irradiated with thermalized neutrons. To reduce neutron flux, SNF storage containers are manufactured using neutron-absorbing materials. For that purposes both volume and surface alloying metal of container walls with absorbing materials are used. The wide distribution when using protective coatings is amorphous boron carbide [2]. The boron content in such coatings does not exceed 9 - 15%.

In our work, we will focus on neutron-absorbing coatings of titanium boride deposited by magnetron sputtering. The technique developed at the Institute of Nuclear Physics of the Republic of Kazakhstan [3], allows obtaining a high concentration of boron in the coating on metallic substrates. Using developed technique allowed us to form titanium boride coating on a stainless austenitic steel substrate - the main structural material of SNF storage containers. Obtained coating is characterized as a mixture of two phases: the hexagonal phase Ti2B5 and the orthorhombic phase TiB12. The first is a matrix, the second is presented as an interstitial phase, i.e. particles of TiB12 with diameter of ~ 0.5 microns uniformly distributed in the matrix. The matrix has a grain structure with a grain size of ~ 10 nm. The total boron content is ~ 80 at. %, that is 4 times higher than the concentration of boron in coatings obtained by plasma spraying of B4C powder.

Modeling using the MCU-REA code with a library of nuclear constants DLC / MCUDAT-2.1 showed a higher efficiency of reducing the thermal neutron flux by a titanium boride coating in compare to existing analogues [4]. Currently, research aimed the experimental confirmation of the effectiveness of titanium boride coatings are conducted. The critical facility reactor of INP RK and the radioisotopic (Pu-Be) source are used as neutron generators.

REFERENCES

[1] N. S. Cebakovskaya, S. S. Utkin, I. V. Kapyrin, N. V. Medyancev, A. V. SHamina, edited by I. I. Linge and YU. D. Polyakova. Review of foreign practices for SNF and RW, Moscow: Komtekhprint, 2015.

[2] J. S. Choi, C. K. Lee, B. L. Anderson, M. Sutton, B. B. Ebbinghaus. Applications of Neutron-Absorbing Structural-Amorphous Metal (SAM) Coatings for Criticality Safety Controls of Used Fuel Storage, Transportation, and Disposal. ICNC 2015 Charlotte, NC, United States September 13-17, 2015.

[3] Larionov A.S., Suslov E.E., Dikov A.S. The method of applying a neutron absorbing coating of titanium boride // Patent Application RK - Utility Model. – 10/18/2019. – entrance. No. 2019 – 44317, bar code – 2105319. – 9 p.

[4] Larionov A.S., Chekushina L.V., E.E. Suslov «Development and Investigation of High-Strength Neutron-Absorbing Composite Coatings Based on Borides of Metals» // Materials Science Forum. – 2019. – Vol. 945. – P. 660-664.

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