PERSPECTIVES OF USING THE MICRO- AND NANO-COMPOSITE STRUCTURES TO MADE THE CLADDING OF FUEL RODS FOR NUCLEAR REACTORS

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It is well-known the significant limitations in possibilities of using the structural materials to make the structures of the core of nuclear reactors due to the specific requirements to the neutron-physical characteristics. These limitations allow making the structures of the core of nuclear reactors using relatively small groups of the structural materials on the base the Zirconium with necessary neutron-physical characteristics, but with the worse mechanical strength relatively the traditional thermal power machinery structural materials. The purpose of this research is to discuss the possibilities of using the micro- and nano-composite structures for making the cladding of fuel rods of nuclear reactors to increase the general operability of the cladding, including the abnormal higher temperatures under emergency states.

The characteristic property of the micro- and nano-composite structures is presence of the micro-and nano-sized structures with clear boundaries. The typical example of the nicro- and nano-composite structures is the piper with the thin coatings, having the nicro- and- nano-sized thicknesses. The particular importance of micro- and nano-composite structures for making the structures of the core including the cladding of fuel rods of nuclear reactors is the possibility of using the more wide structural material, including the traditional for thermal power machinery structural materials with the higher strength and corrosive-protecting properties. This possibility is due to the micro- and nano-sizes of the structures, which lead to small masses of these structures and have no significant effects on the neutron-physical balances in the core of nuclear reactors.

The most discussed way of using the micro- and nano-composite structures for making the cladding of fuel rods is using the cladding made from traditional Zirconium-based alloys with the thin protective coatings, having the nicro- or nano-sized thicknesses, made from corrosion-protective materials such as stainless steels. The main problem of using such structures is predicting the strength properties of these structures under the exploitation of normal and emergency loadings during their operation. It was proposed the mathematical model of deforming the cladding of fuel rods made from the Zirconium-based alloys with the thin protective coatings. This model is based on the well-known differential equations of the theory of elasticity, but the boundary conditions for these equations is formulated on the basis of considering the interactions between the thick-walled structure and the thin-walled coatings, imagined as the thin shells. It was shown, that presence of the thin protective coatings lead to noticeable decreasing the stresses from the operational loads in the cladding of fuel rods. This found circumstance allows the wide perspectives of using the micro- and nano-composite structures for making the cladding of fuel rods of nuclear reactors.