APPROXIMATE ESTIMATES FOR THE TEMPERATURE STATE OF THE CERAMIC NUCLEAR FUEL IN CYLINDRICAL FUEL ELEMENTS

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It is well-known that operability of ceramic nuclear fuel compact products is significantly depended by its temperature state during operating, because the ceramic has low thermal conductivity, which can lead to significant differences between the temperatures on the inner and outer surfaces in compact products. Due to this significant differences in temperatures on inner and outer surfaces the thermal stresses can be produced, which can lead to damaging the nuclear fuel compact products. The temperature state of the nuclear ceramic fuel is the difficult subject both for the theoretical, experimental researches as well as for measure on operating, and the all of existing approaches for estimating the temperature state of the ceramic nuclear fuel compact products on operating are approximate only. These circumstances make actual the theme of this research deals with approximate estimating the temperature fields in the ceramic nuclear fuel compact products.

It is proposed the mathematical model of the heat conduction for approximate estimating the temperature state of ceramic nuclear fuels in widely-used fuel elements with the pellets of cylindrical shape; in this mathematical model the radial heat flows only are considered. This mathematical model is presented in the form of the differential equation of the heat conduction, represented using the radial coordinate, and the necessary boundary conditions are corresponded to zero hear flow on the internal and the heat transfer on the external surface of the fuel pellet. The differential equation has the member, corresponding to the internal heat sources, for considering the heat from the nuclear fission reactions in the nuclear fuel. The intensity of volume heat sources in fuel element was taken into account by using the average values corresponding with the heat power and the structural characteristics of a nuclear reactor core. The heat conduction coefficient is defined considering the heat conductivity in the ring gaseous gape, in the cylindrical wall of the cladding, as well as considering with the heat transfer from the cladding to the moving heat carrier.

The obtained analytical representation of the temperature field in the ceramic nuclear fuel pellet for given internal heat sources intensities and the temperature of the heat carrier is defined by the sizes of the pellet, the heat conductivities of the fuel, the gas in the gap and the cladding, as well as by the heat transfer from the cladding to the moving heat carrier. It was shown that the heat conductivity of the fuel has significantly influences both the average temperature and the difference between the inner and outer temperatures in the fuel pellet. At the same time, other parameters have significant influence only on the average temperature of the fuel pellet. Due to these, it is necessary to consider the temperature dependence of the thermal conductivities of the materials constituted the fuel elements for more precisely estimations the temperature state of the fuel pellets, which will lead to nonlinear equations will required the numerical methods for their solving.