EFFICIENCY OF TRANSURANIUM NUCLIDES TRANSMUTATION

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Introduction.

One of the ways to create a wasteless nuclear power is based on transmutation of spent fuel nuclides. In particular, it is considered that the radioactivity of the nuclear power wastes should be the same (or smaller), than radioactivity of the uranium and the thorium extracted from entrails of the Earth. The problem of fission fragments transmutation efficiency was considered in article [1], where, in particular, the concepts of transmutation factor and the "generalised" index of biological hazard of the radioactive nuclides were entered. The transmutation efficiency has appeared to be a function of time and, naturally, dependent on nuclear power activity scenario, from neutron flux, absorption cross-sections of the nuclides under transmutation and on the rate of their formation in reactors. In the present paper the efficiency of the transmutation of transuranium nuclides is considered.

Description of the Work

Relatively long time ago one paid attention to the fact, that the incineration of uranium and thorium in nuclear reactors results in a decrease of the radioactivity of the planet. It is true if one takes into consideration, that the half-life period of the radioactive families ancestor nuclides (uranium and thorium) located in lithosphere, are as a rule much more than all fission fragments and transuranium nuclides, generated as a result of nuclear reactions. Therefore after considerable time (about one million years) radioactivity of the created nuclides will be lower than a radioactivity of the initial (incinerated) nuclides. As a matter of fact - the nuclear power is a large system of transmutation of heavy radioactive nuclei. However, this system of transmutation has more important task - production of energy. As a transmutation system the nuclear power has essential lack - scoring in radioactivity will be reached in a long time, that any sense in such transmutation is lost.

The destruction of plutonium is realised in a closed fuel cycle, as a result of which some equilibrium quantity of plutonium is established while operating with nuclear power. The inclusion of trans-plutonium nuclides (SA) in a closed fuel cycle can be considered from two points of view. First. SA- are fissionable nuclei and it is reasonable to incinerate them in reactors for power generation. However, their quantity is small and consequently it is necessary to conduct economical estimations of such a fuel material cost. So it is only an economical problem. Second. - SA are radioactive and very hazardous nuclides (large biological hazard). Therefore there is a natural problem: to keep these nuclides in stores, or to transform them into fission fragments and other nuclides, which one will be formed while irradiation in the reactor? For answering this problem the trial functions (TF) (some kind of Green functions) were constructed.

TF is a ratio of a radioactivity (or generalised indexes of biological hazard) of the fission products and the new heavy nuclides, formed during some standard irradiation of investigated mother nuclide, to a radioactivity of a mother nuclide. Considering, that at TF = 1 we determine the time T_o, after which there is a reason to transmute, resulting in a decrease of the radioactivity or the biological hazard. As a reference condition of irradiation we obtained a

mean density of the neutron fluxes and the duration of placing the fuel in a representative Pressurise Water Reactor and a Fast Breeder Reactor with sodium coolant.

Results

The conducted calculations have shown an essential influence on the time T_o not only by the half-life period of a mother nuclide (this conclusion is obvious enough), but also by the vector of heavy nuclides, formed during mother nuclide irradiation.

The weak dependence of the time T_o from a radiation time and neutron flux is marked at their variations in reasonable limits. For non- fissile nuclides the time T_o essentially depends on a neutron spectrum .

Conclusions

The conducted calculations allow to use an offered functions TF for analysis of efficiency and expediency of SA transmutation at the different scenarios of a fuel cycle.

References:

[1] Yu.A.Kazansky, D.A.Klinov Efficiency of fission products transmutation // Izvestia Veschich Uchebnich Zavedenii. Yadernaya Energetica, 2000 y., № 4, p.38-46.