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Analysis of Physical Parameters of the New High-Flux Pulse Reactor

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The development of a design for a new, high-class reactor, NEPTUNE, is required to effectively continue the neutron research program once the IBR-2M's service life ends and to satisfy new needs. This reactor, like the IBR-2M, will be unique, more powerful, and competitive among other facilities in the world. It will be a tool for physicists, biologists, and creators of new substances and nanomaterials.

To achieve this goal, we plan to increase the flux density of the NEPTUNE by an order of magnitude compared to the IBR-2M. This will allow us to explore completely new objects and conduct a more extensive analysis of research results in real-time. The main goal of our Laboratory is to provide a solid scientific basis for the importance of this new source for scientific research.

In this paper, we will analyze the optimal design of a high-flux, pulsed neutron source and further elaborate on the concept of a pulsed fast reactor. The reactor development involves research on the kinetics and dynamics of power pulses, development of nitride fuel based on 237Np, optimization of main elements' design, and optimization of moderator complex configuration.

One way to optimize physical characteristics is by changing the isotopic composition of fuel to reduce irregularities in fuel rods' energy release, achieving desired average lifetime for neutron generation, and creating conditions for stable reactor operation. To obtain the required neutron spectrum and flux, thermal and cold moderators were optimized. At the same time, it is important to justify the design features of the reactor from the perspective of its safe operation.

This paper outlines the basic design and estimated parameters of a pulsed reactor using 237Np as a nuclear fuel. The main characteristic of the 237Np isotope, compared to traditional nuclear compositions based on 235U and 239Pu, is its threshold nature for fission cross-section (it effectively splits at a neutron energy above 0.4 MeV). This results in the following benefits for the reactor: the lifetime of fast neutron generation in the neptunium zone is approximately 10 nanoseconds, leading to a shorter neutron pulse; the low fraction of delayed neutrons reduces background power between pulses compared to the IBR-2M reactor; there is a little effect on reactivity during fuel burning due to the long half-life of 238Pu; and the efficiency of reactivity modulation can be increased by using materials with good neutron-moderating properties.

Primary author: CHERESHKO, Dimitar (JINR)

Presenter: CHERESHKO, Dimitar (JINR)

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