Mechanical and Temperature Calculations of the Reactivity Modulator Construction of the Research Pulsed Reactor NEPTUN

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The NEPTUN reactor is a pulsed periodic research reactor under development with a sodium coolant and a core based on neptunium nitride fuel. The reactor is designed for experiments using extracted beams. Average thermal power is 10–15 MW, pulse half-width is 200 μs, pulse frequency is 10 Hz, time-average thermal neutron flux density is ~10^{14} $cm^{-2} \cdot s^{-1}$. The reactor vessel and its core are divided into two parts. A reactivity modulator (RM) is located in the space between parts of the core.

The pulsed operating mode of the reactor is achieved by the reactivity modulator. The RM is a disk which rotates in a vertical plane with a box-shaped rim, in the cavity of which there are blocks of titanium hydride (TiH2). The disk diameter is 3000 mm, thickness is 50 mm, rotation frequency is 10 Hz. The rim contains a «window» 440 mm high, which has no titanium hydride. When the «window» passes through the core, a neutron pulse is generated.

The power pulse (therefore the stability and safety of the reactor) is sensitive to such parameters as the reactivity and the rate of change of reactivity. The above parameters depend on the stability of the reactivity modulator. RM is a non-standard design, not used on serial types of reactors. Therefore, there is a need for research of the reactivity modulator construction.

The report presents the results of numerical calculations of a reactivity modulator construction:

- Natural frequencies and oscillation shapes of the reactivity modulator disk. Obtained during modal analysis in the Modal Analysis of the ANSYS software;
- Distribution of stresses, strains and displacements in the RM construction during its rotation at idle mode of the reactor. Also, the safety factor of the RM during its rotation is estimated. The results were obtained during mechanical calculations in the Explicit Dynamics module of the ANSYS software;
- Temperature distribution in the RM “window” area at nominal capacity mode of the reactor. The calculations were carried out for two versions of the RM: with and without nickel inserts. The results were obtained during thermal calculations in the CFX module of the ANSYS software.