INCREASE OF QUALITY FACTOR IN PIK REACTOR'S REFLECTOR BY SM-2 TYPE FUEL ELEMENTS

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Ratio of maximum thermal neutron flux density in a reflector to reactor power Φ_{th}^{max}/P (quality factor) is one of the most important characteristics of a research reactor for physical investigations. The value of Φ_{th}^{max}/P in the PIK reactor's [1] reflector where the majority of experimental facilities are located is less than the one of a number of both functioning and projected high flux reactors (Table). Decreasing the quality factor is primarily explained by 2 functions of the PIK reactor (trap and beam type) and by application of stainless steel and copper (highly absorbing neutrons) as construction materials of a vessel and fuel elements.

Table

Quality factor in reflector of research reactors [2]

Reactor	PIK	IR-8	MAPLE	GHFR	ORPHEE	ANS	FRM
$(\Phi_{th}^{max}/P)\cdot 10^{13}$ $n/(cm^2\cdot s\cdot MW)$	1.3	1.4	2.0	2.6	2.1	2.8	3.3

To increase quality factor in a reflector one should provide for more intensive neutron leakage from a core and decrease neutron flux depression, caused by a highly absorbing core. This is done by applying construction materials which absorb neutrons less intensively, by reducing the core (or thickness), by changing the core shape, by diminishing the fuel concentration in the core, by changing power density distribution in the core etc.

Paper [3] shows that in the PIK reactor with aluminium vessel and aluminium core without changing its volume (equals 50 l.) the value Φ_{th}^{max}/P reaches the $2\cdot 10^{13}$ n/(cm^2·s·MW). However this variant requires considerable expenses on developing quite a new type of a reactor.

Paper [4] offers to accelerate the moderation of installing a light water intermidiate layer $\simeq$ 1.5 cm thick between the vessel and a heavy water reflector of the PIK reactor; this allows to increase the value Φ_{th}^{max}/P up to $1.7\cdot 10^{13}$ n/(cm^2·s·MW). Yet calculations have shown that in this case reactivity margin ($\Delta k/k$) decreases by $\simeq$ 3%, which considerably reduces the efficiency of the PIK reactor.

The possibility of increasing the value of Φ_{th}^{max}/P in the reflector of the PIK reactor by means of changing the vessel material and by means of a new arrangement of the core retaining SM-2 type fuel elements has been studied. Calculations of neutronic characteristics of the PIK reactor have been made by XSDRNPM [5] and MCU [6] codes.

When changing a steel vessel into an aluminium one, reactivity margin increases by $\simeq$ 4% which provides more than necessary reactivity margin for reaching the planned fuel burnup depth in the PIK reactor. Therefore a part of this reactivity margin may be used to increase the quality factor in the reflector.

Construction materials highly absorbing neutrons are used in the SM-2 type fuel elements. A high value of the multiplication factor k_∞ is provided by a considerable fuel concentration. Consequently a quality factor increase in the reflector with such fuel elements is generally obtainable by decreasing the core volume, changing its shape and power density distribution.

Use of the intermidiate hydrogen containg layer is an alternative to decreasing the core volume.

The calculation showed that having decreased the core volume of the PIK reactor up to 39 l. at the expense of the $\simeq$ 2 cm thick intermidiate berillium layer[1] the value Φ_{th}^{max}/P may be increased up to $(1.8 \pm 0.12) \cdot 10^{13}$ n/(cm^2·s·MW) without changing the core hight and the size of the aluminium vessel. Such thickness of the berillium layer corresponds to changing five layers of fuel elements in the outside fuel assemblies into berillium displaces.

This variant allows to use all the previous construction and technological findings concerned with the vessel and makes modernisation of the fuel elements unnecessary. High specific fuel contens compensates for the lesser k_∞ compared with aluminium core and in a partial refueling regime provides for the lifetime of $\simeq$15–20 days. Besides SM-2 type fuel elements are more preferable in the emergency compared with aluminium ones.

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