IRRADIATED TECHNOLOGY OF SAMPLES IN CENTRAL EXPERIMENTAL CHANNEL OF PIK REACTOR

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The high flux PIK reactor [1–3] is aimed for fundamental and applied physical researches. The project reactor power is 100 MW. The maximum thermal neutron flux density

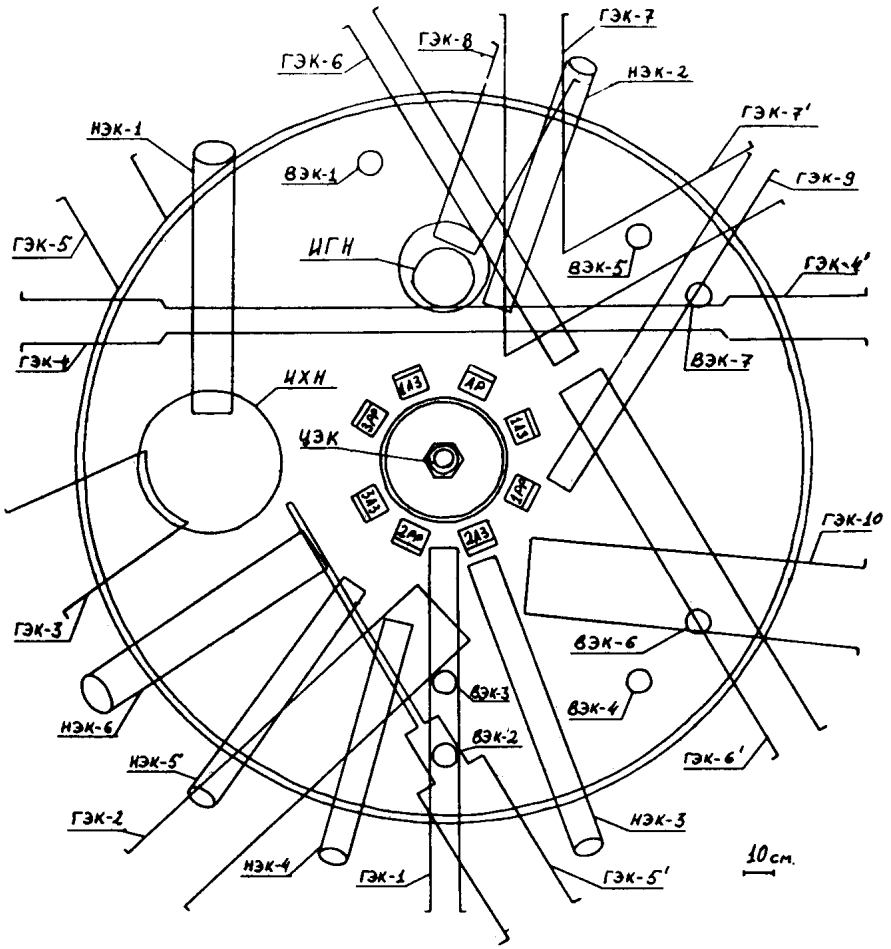

Fig.1. Location of PIK reactor experimental channels.
ЦЭК — central experimental channel,
ГЭК — a horizontal experimental channel,
НЭК — a inclined experimental channel,
ВЭК — a vertical experimental channel,
ИХН — cold neutron source,
ИГН — hot neutron source

($4.5 \cdot 10^{15}$ n/cm^2·s) is achieved in central experimental channel (CEC) [4]. The reactor design and the experimental channel locations are shown in Fig.1.

The supporting grid guide (SGC) occupies the core center. It is a hexahedral zirconium prism of 115 mm in "spenner" size and it has the central cylindrical light water gap of 104 mm in diameter. The gap is coaxial to the SGC axis.

Irradiation technology of the samples is considered in this work, the CEC radiation characteristics and the reactivity effects of sample loading are described.

According to the project the CEC consists of two coaxial tubes (so-called the fild tube). The bottom of the external zirconium alloy (Э-125) tube is located 450 mm lower than the core middle plane. The distance from the lowest end of internal tube to the bottom of the internal tube is equal to 145 mm. The lift trunk for movement of irradiated samples is placed into the internal tube. The samples overloading is performed in the upper position of the lift trunk. The channel design is shown in Fig.2.

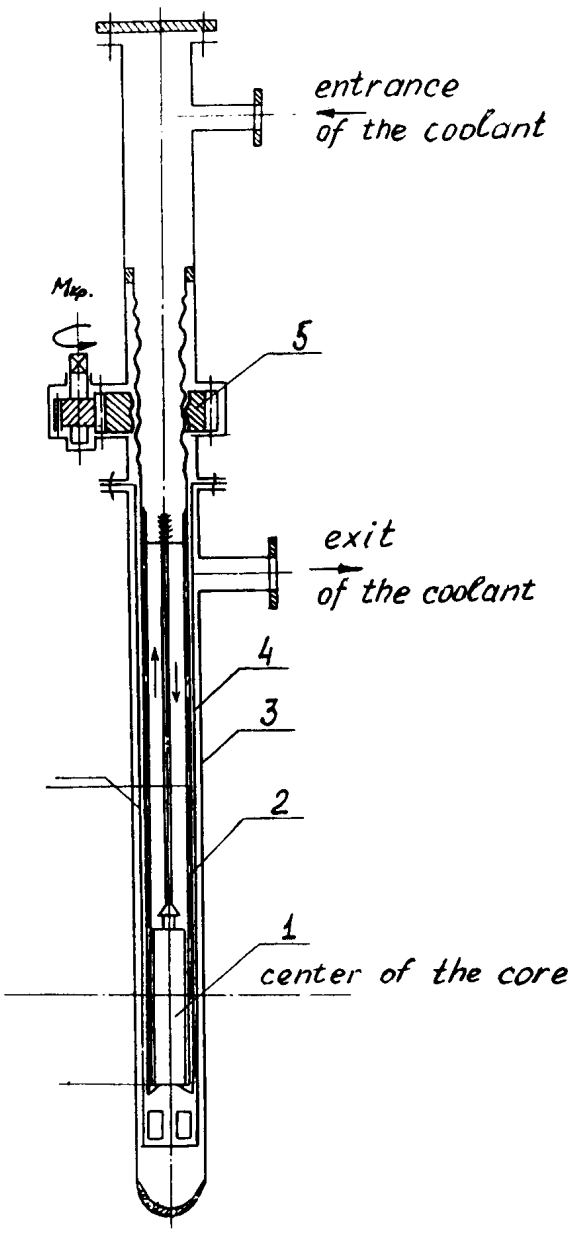

Fig.2. CEC scheme with lift trunk.
1 — container with samples,
2 — lift trunk,
3 — external tube,
4 — internal fixed tube,
5 — trunk movement device

The CEC design makes it possible to irradiate the samples into the CEC during the reactor operation and with removed upper plug of the channel. In this case the pit pool serves as the volume compensator, the emergency cooling system and the volume compensator of the CEC are to be disconnected.

The CEC thermal and fast neutron flux densities, the CEC energy release in constructive materials are given in Table 1. The energy release in thin ^{235}U sample is also presented.

The thermo-hydraulic contour leads off 200 kW from constructive elements and up to 200 kW from irradiated samples. The flow rate of the 50 atm pressured water in the CEC is up to 6.5 m^3/s. The inlet water temperature is equal to 50°C, the outlet one increases up to 103°C.

The CEC irradiated samples to overload are lifted on 100 sm upper the core. To calculate the samples cooling and its activation, the radiation characteristics for the 100 MW reactor power at this point are estimated — the fast neutron flux density (> 1.2 MeV) equals $8 \cdot 10^9$ $n/cm^2 \cdot s$, the thermal one is 10^{11} $n/cm^2 \cdot s$ and the energy release is 0.15 Mw/gm.

The reactivity effects of samples loading have been measured on the PIK reactor physical model and are given in Table 2. The quantities are normalized to the ones obtained in the absence of the samples in the CEC. The height of samples was greater a 500 mm.

The presented data enable to choose the safety overloading regimes during the reactor operation, including the sample sizes and the velocity of their movement. The planned 100 mm/s sample velocity agrees with the ПБЯ-03-57 requirements — the rate of reactivity variation should be less than 0.03 β/s.

The CEC design and its systems provide the heat removal up to 200 kW from irradiated samples and make the sample overloading during reactor operation possible.

Table 1

Neutron flux densities (10^{12} $n/cm^2 \cdot s \cdot MW$) and energy release ($10^{-2} W/gm \cdot MW$) in CEC of PIK reactor

	CEC in water	CEC in dry aluminium channel 21×1 mm
R (mm)	0	0
Z (mm)	0	0
R_{Cd}^{Au}	8.2	7.8
Φ_0	34.4	31.6
Φ_{th}	42	38.5
$\Phi_{1.2}$	5 [4]	
q_c		42
q_{Al}		45 [3]
q_{Fe}		53 [3]
q_{Zr}		32
q_{H_2O}		105
$q(U-235)$		$1.5 \cdot 10^5$ in the core — $6 \cdot 10^3$ (R = 108 mm, Z = 0 mm)

Notation in table:

R — distance from CEC axis,

Z — distance from core middle plane,

R_{Cd}^{Au} — gold cadmium ratio,

Φ_0 — Westcott neutron thermal flux density,

Φ_{th} — Maxwell neutron thermal flux density,

$\Phi_{1.2}$ — fast neutron flux density (E>1.2 MeV),

q_c, q_{Al}, q_{Fe}, q_{Zr}, q_{H_2O}, $q(U-235)$ — energy release in carbon, iron, zirconium, water and uranium-235.

Table 2

Reactivity effects of sample loading in CEC [4]

	CEC loading	Coolant	ρ (β_{eff})
1	Repl. of water to air		$+1.1 \pm 0.1$
2	Empty cylinder of stainless steel $\varnothing_{ext}$ = 26 mm,	water	-0.8 ± 0.2
	$\varnothing_{ext}$ = 11 mm	air	$+0.3 \pm 0.2$
3	Stainless steel tube	water	-0.7 ± 0.2
	30×3 mm in dia	air	$+0.3 \pm 0.3$
4	Iron stem	water	-0.4 ± 0.2
		air	$+0.1 \pm 0.2$
5	Copper stem	water	-0.2 ± 0.1
		air	-0.6 ± 0.2
6	Aluminium stem	water	$+0.2 \pm 0.1$
7	Dry aluminium channel 21×1 mm in dia	water	$+0.3 \pm 0.1$
8	Extraction of alum.tube of 50×3mm in dia from CEC	water	-0.4 ± 0.1
9	Cadmium cylinder of 36 mm in dia σ = 0.6	water	-2.7 ± 0.3
10	Aluminium cylindrical ampoule, external tube 35×5mm in dia, int.tube 21×1mm in dia, space between the tubes is filled with H_3BO_2 aqueous solution	water	-0.9 ± 0.2
11	The SM fuel element of nominal fuel quantity	water	0.52 ± 0.05
	1/3 fuel quantity	water	0.22 ± 0.05

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