DEVELOPMENT OF Sn-MC COUPLING TECHNIQUE FOR PIK REACTOR FAST NEUTRON FLUX CALCULATIONS

K. A. Konoplev, I. A. Potapov, V. F. Samodurov, S. L. Smolsky, A. S. Zaharov

The PIK reactor heavy water reflector (diameter 240 cm, height 250 cm) [1] includes the 10 horizontal experimental channels (HEC, Fig.1), the 6 inclined channels (IEC) and the 6 vertical channels (VEC). The welds of the attaching arrangements of the channels to the tank (AAT, Fig.2) are the tank's element and they are intensively irradiated with fast neutrons.

For determination of the fast neutron flux the discrete ordinates method (Sn) and the Monte Carlo (MC) method are coupled. This approach makes it possible to perform an effective and accurate shielding calculation for large and complex geometry.

The angular fluxes of Sn-method are calculated along the given directions with the μ, η, ξ - cosines and the weight W (Fig.3). For the MC multi-surface source preparation the angular fluxes are rearranged in the polar (l) and azimuthal (m) levels, in energy and in space. The source can be set on six surfaces simultaneously or selectively (Fig.4). After normalization there are the cumulative source distributions.

For realization of this approach the authors have written the coupling code - SN_MC. For flux calculations the DOT-3.5 [2] and MORSE [3] codes were used; the neutron group libraries were prepared from the VITAMIN-C [4] with the AMPX-II [5] codes.

The measured neutron fluxes into and around HEC-1 [6] on the PIK reactor critical facility [7] and the calculated ones are in good agreement.

The AAT welds (see table) will have the neutron fluense grater then 10^{18} n/cm^2 ($E \geq$ 0.5 MeV) for 30 years of the PIK reactor working period with the 100 MW power. The proving of the serviceability of these welds is needed [8].

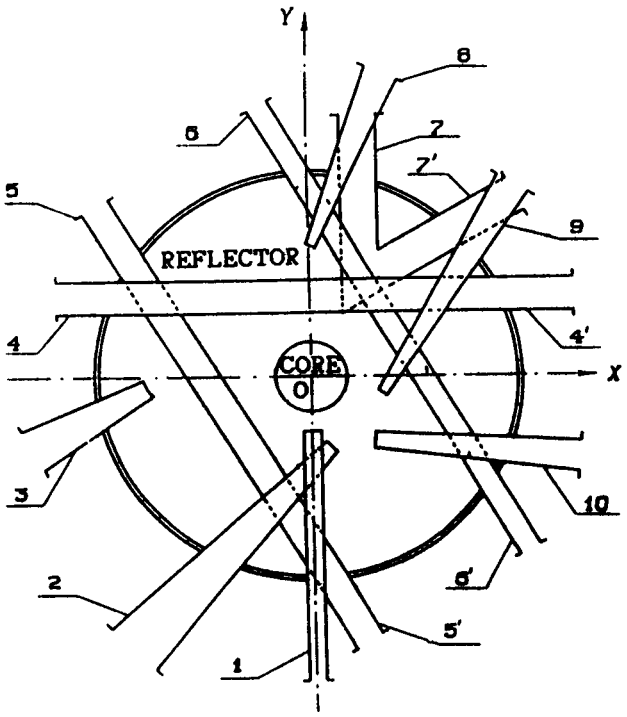

Fig.1. Horizontal experimental channels (HEC) of PIK reactor (0-core center, center of reference system)

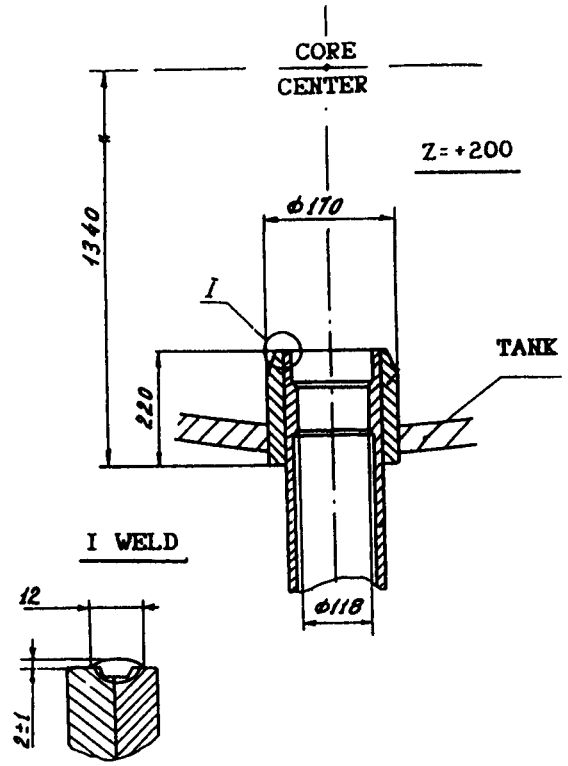

Fig.2. Attaching arrangement of HEC-1 to tank

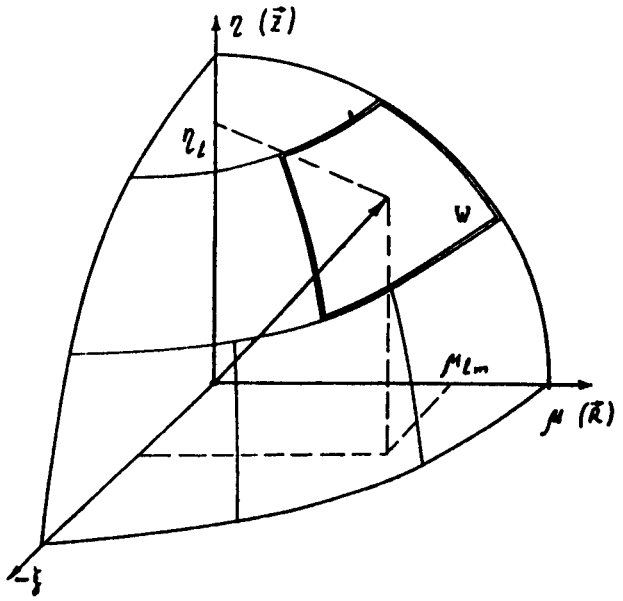

Fig.3. 1/8 part of S6 quadrature set

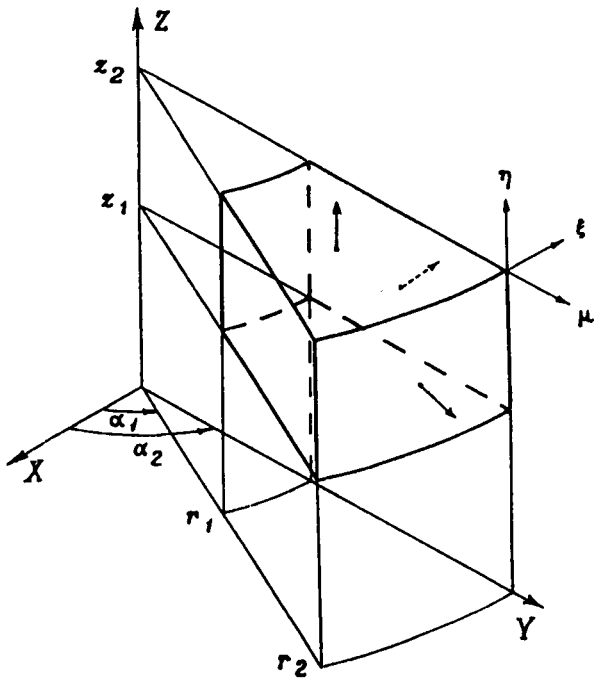

Fig.4. Six surfaces in cylindrical geometry for MC surface source

Table

Neutron fluxes ($E \geq 0.5$ MeV) on the AAT welds
of the PIK reactor experimental channels

N	Channel	Weld Coordinates			Neutron flux, $n/cm^2 \cdot s \cdot MW$	MC Standard Deviation, %
		X, cm	Y, cm	Z, cm		
1.	HEC-1	0.0	−112.0	26.0	$1.84 \cdot 10^8$	7.1
2.	HEC-2	-34.13	−102.05	15.30	$1.37 \cdot 10^8$	11.4
3.	HEC-3	-120.46	−11.46	16.62	$4.76 \cdot 10^7$	5.4
4.	HEC-4-4'	96.0	61.15	0.0	$1.76 \cdot 10^8$	10.3
5.	HEC-5-5'	-105.09	49.02	−60.0	$6.23 \cdot 10^6$	10.2
6.	HEC-6-6'	105.09	−49.02	−40.0	$< 10^7$	–
7.	HEC-7-7'	21.19	40.18	−74.86	$1.52 \cdot 10^8$	2.2
8.	HEC-8	6.72	11.67	52.07	$7.53 \cdot 10^6$	6.3
9.	HEC-9	88.75	56.57	51.63	$5.02 \cdot 10^7$	10.8
10.	HEC-10	90.69	−53.36	16.66	$1.07 \cdot 10^8$	10.4
11.	IEC-1	−69.90	57.0	89.88	$< 10^7$	–
12.	IEC-4	−25.86	−96.50	88.40	$< 10^7$	–
13.	IEC-6	−83.90	−58.75	86.95	$9.48 \cdot 10^7$	11.0
14.	VEC-1	−24.75	96.99	89.50	$< 10^7$	–
15.	VEC-2	0.0	−84.30	93.50	$(1.2 \div 2.0) \cdot 10^7$	
16.	VEC-5	82.40	−53.63	90.0	$< 10^7$	–

REVERENCES

1. *Erikalov A.N. et al.,* Preprint PNPI, St.-Petersburg, 1992. 38 p.
2. *Rhoades W.A., Mynatt F.R.* ORNL-TM-4280, Sept.1973.
3. *Emmett M.B.* ORNL-4972, Febr. 1975.
4. VITAMIN-C: RSIC-DLC-41. 1976.
5. *Greene N.M. at al.,* ORNL-TM-3706, December 1978, revised.
6. *Konoplev K.A., Potapov I.A., V.F.Samodurov. at al.,* PNPI Research Report 1992-1993, Gatchina. 1994. P.195.
7. *Abramkov E.L. et al.,* //Metodicheskie i prikladnye raboty LNPI, Leningrad. 1988. P.157.
8. PN AE G-7-008-89. Moscow, Energoatomizdat, 1990. P.65.