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# THE NEW WATER MODERATOR OF THE **IBR-2** REACTOR WITH A CANYON ON THE LATERAL SURFACE. DESIGN AND PHYSICAL PARAMETERS

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The water premoderator, an integral part of the new cold methane moderator of the IBR-2 reactor, is a cavity filled with water at room temperature. The casing of the premoderator is structurally combined with a vacuum casing of the methane moderator and it is a box made from aluminum alloy (see. fig. 1). Basic applications of the water premoderator are: a) to transform the fast fission neutron into thermal neutron spectrum and "protect"methane from being bombarded by fast neutrons from the reactor core, b) to serve as a thermal moderator for channels 1 and 9 of the IBR-2 reactor. The nearest to the reactor core cavity in the premoderator

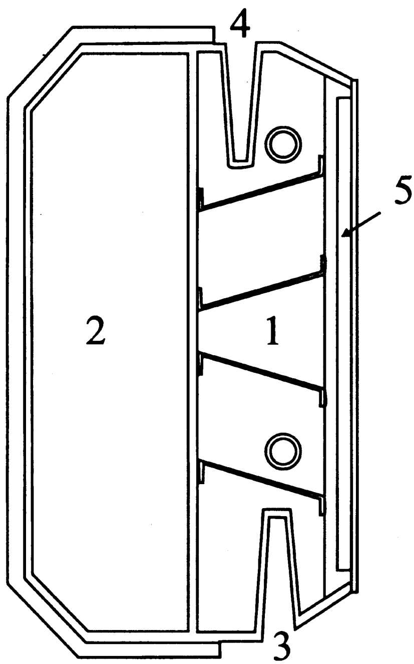


Fig. 1. The horizontal cross section of the cold moderator. 1-cavity in the water premoderator; 2-cavity filled with methane; 3, 4-groove-like pockets (canyons) on the sides of channels 9 and 1, respectively; 5-cavity filled with B4C

is filled with powder B4C whose thickness is 10 mm. This is traditional for water moderators of the IBR-2 reactor and is dictated by the necessity to shield the core from thermal neutrons from the moderators. Thus, the water premoderator and the cold methane moderator make a single unit. The premoderator immediately adjoins the core of the reactor. Further transfor-

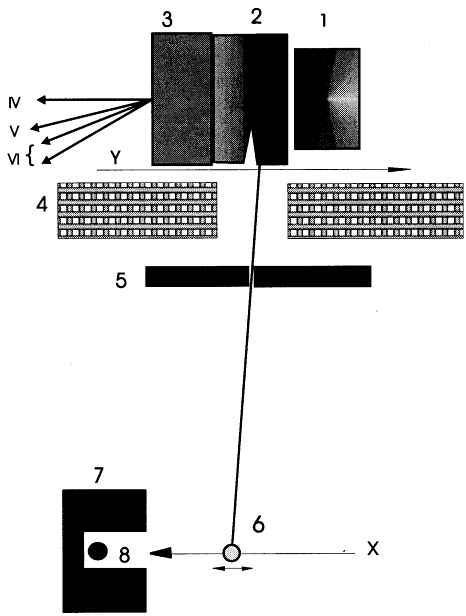


Fig. 2. The sketch illustrating the experimental layout to determine the flux density distribution over the lateral surface of the premoderator on channel 9 of IBR-2. 1- reactor core; 2-premoderators with a canyon; 3-methane moderators; 4-biological shields of the reactor with an aperture of the shutter; 5- collimators with a narrow (3 mm) vertical slit; 6- vanadium thin cylinder (scatterer) located on a mobile device; 7-shields of the detector, 8-helium detectors; Roman figures label the directions of the appropriate beams

mation of the neutron spectrum into the "cold"neutron spectrum is carried out by a solid-state methane moderator cooled to the temperature 30-60 K. The arrangement of the cold moderator is that four beams (IV, V, VIa, VIb) (see. fig. 2) "look"at the surface of the methane moderator. Except for the listed beams there are two coaxial beams (I and IX) which "look"at lateral walls of the warm water premoderator from the opposite sides (the axes of these beams are perpendicular to the lateral surfaces of the premoderator).

On the 9th channel of IBR-2 the neutron reflectometer REFLEX is located. The specific feature of the reflectometer consists in that it only "sees"neutrons emitted from a limited region of the moderator surface. This region is a rectangular extended along a vertical with a horizontal dimension of about 7 millimeters. The rest of the moderator surface is not used in the experiment.

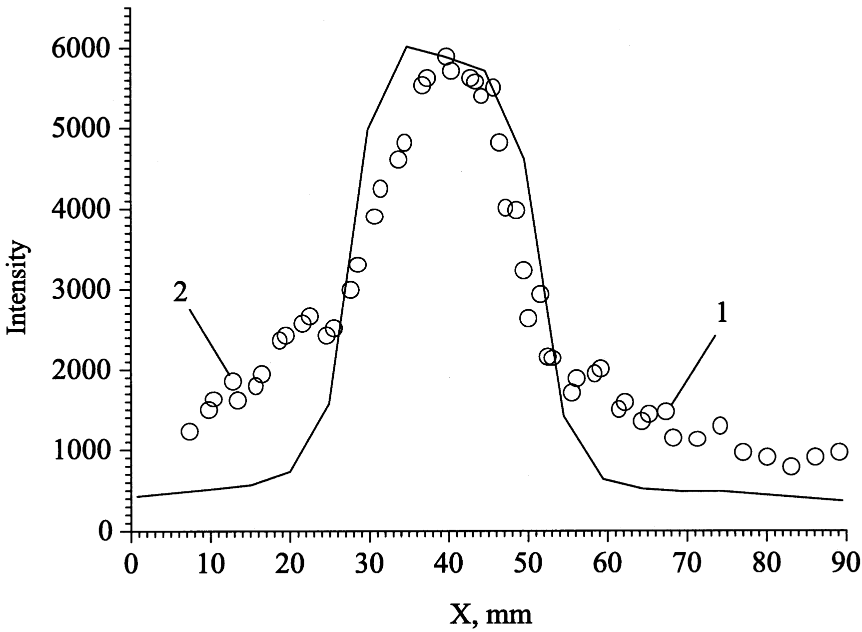


Fig. 3. The dependence of the counts of the detector on the vanadium cylinder coordinate after subtraction of the background. The position of the maximum count of the detector coincides with the canyon position. Zero values of the count on the left and right margins of the distribution correspond to the situation of the vanadium cylinder that is projected through the slit of the collimator on the aperture of the shutter limiting the viewing area of the premoderator. The numerical symbols on the diagram mark the vanadium cylinder coordinates for which the spectral gain of the flux in the point of maximum (see fig. 4) is determined. The solid line is the Monte Carlo simulation by the code [1] strongly corresponding to the experiment geometry (fig. 2)

Taking advantage of the fact that the reflectometer REFLEX only "sees"neutrons emitted from a limited region of the moderator surface the design of the premoderator was complicated to increase the flux on the sample. Namely, on its lateral surface a vertical groove-like pocket (canyon) with a depth of 80 mm by the width 15 mm and height 200 mm was cut at a distance of 52 mm from the wall closest to the reactor core (see fig. 1). A similar pocket was also made on the opposite side of the premoderator. It is thought that this specific feature of the design will lead to a local increase of the neutron flux from the discussed area (canyon) of the premoderator.

In figure 2 the experiment to study the neutron flux distribution on the

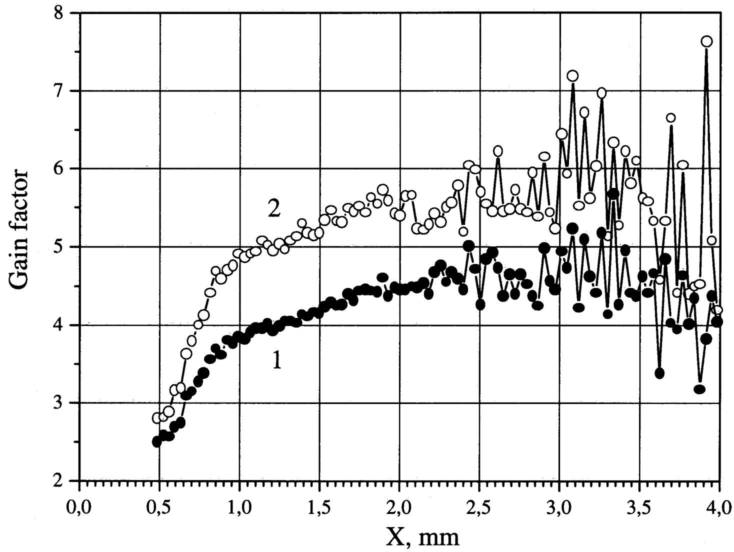


**Fig. 4.** The spectral gain of the local flux for the position of the canyon on the premoderator relative to that outside the canyon. Curves 1, 2 correspond to points 1, 2 in fig. 2

lateral surface of the premoderator on the side of channel 9 is sketched. A collimator with a narrow vertical slit (width – 3.0, height – 150 mm) is fixed at a distance of 7.5 meters from the moderator in the experimental hall of the reactor. At a distance of 20.1 meters from the collimator a vanadium cylinder with a diameter of 5 mm and a height of 100 mm is placed in order to scatter neutrons in the direction of the detector. The cylinder can be automatically moved across the neutron beam in the horizontal plane with a precision of 0.05 mm. The neutrons scattered by the vanadium cylinder are registered with a detector inside a shield located at a distance of 400 mm from the average position of the vanadium scatterer. The window in the shield of the detector is oriented so that the vanadium cylinder is always visible to the detector. It is obvious (see. fig. 2) that the projection of the vanadium cylinder through the slit of the collimator (a vertical spot-like stripe with a width of 5mm) on the surface of the premoderator moves synchronously with the moving vanadium cylinder. Thus, the counting rate of the scattered neutrons of the detector for different positions of the vanadium cylinder corresponds to the distribution of the neutron flux on the surface of the premoderator in the horizontal plane. In figure 3 the measured distribution of the neutron intensity is shown as a function of the coordinates of the vanadium cylinder position (integrated over the thermal neutron spectrum). From the figure it is seen that the integrated intensity distribution on the moderator surface has a clearly expressed maximum for certain coordinates. The intensity gain for these coordinates in comparison with an average intensity is approximately 3.5. Figure 4 presents the neutron wavelength dependence of the intensity amplification coefficient in the point of the neutron flux distribution maximum in comparison with the intensities corresponding to the coordinates 1 and 2 shown in fig. 2. It is seen that as the wavelength increases the relative gain grows and at 3 angstroms it reaches a value of 4.5 and 5.5 for points 1 and 2, respectively.

The obtained results have confirmed the fact that the local neutron flux emitted from the canyon area increases. This will allow the use of this area of the moderator to form a neutron beam for the REFLEX spectrometer (see fig. 3, 4) that will essentially increase the luminosity of the entire facility.

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## References

[1] J.F.Briesmeister, Ed., "MCNP - A General Monte Carlo N-Particle Transport Code, Version 4C,"LA-13709-M, Los Alamos National Laboratory (April 2000).

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Корнеев Д. А. и др. E3-2003-56

Водяной замедлитель реактора ИБР-2 с каньоном на боковой поверхности. Конструкция и физические параметры

Водяной предзамедлитель, который является одним из элементов нового метанового криозамедлителя реактора ИБР-2, одновременно служит тепловым замедлителем для 9-го канала. Излучение нейтронов в сторону канала происходит с боковой поверхности замедлителя. Специфическая особенность рефлектометра РЕФЛЕКС-П, расположенного на этом канале, заключается в том, что он «видит» нейтроны, излучаемые только с ограниченного участка поверхности замедлителя. Форма этого участка представляет собой вытянутый вдоль вертикали прямоугольник с горизонтальным размером порядка 7 мм. С целью повышения потока нейтронов на образце на боковой поверхности замедлителя (в направлении, параллельном стенке активной зоны реактора) был создан вертикальный щелевой карман (каньон) глубиной 80 мм, шириной 15 мм и высотой 200 мм. Приводятся конструктивные параметры замедлителя и результаты относительных измерений распределения потока нейтронов вдоль боковой поверхности как функции расстояния от активной зоны реактора.

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The New Water Moderator of the IBR-2 Reactor with a Canyon on the Lateral Surface. Design and Physical Parameters

An element of the new cold methane moderator of the reactor IBR-2, the water premoderator, serves as a thermal moderator for the 9th and 1st channels. Neutron radiation in the direction of the 9th channel comes from the lateral surface of the moderator. A specific feature of the reflectometer REFLEX located on the 9th channel is that it only «sees» neutrons emitted from a limited region of the moderator surface. This region is a rectangular extended along a vertical with a horizontal dimension of about 7 mm. To increase the flux on the sample, a groove-like pocket (canyon) with a depth of 80 mm by the width 15 mm and height 200 mm was cut in the premoderator on its lateral surface. The design of the moderator and the results of measurements of the neutron flux distribution on the lateral surface of the moderator are presented.

The investigation has been performed at the Frank Laboratory of Neutron Physics, JINR.

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