The Laboratory Investigation of the Experimental Nuclear Reactor VVR-S

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Results are given in this paper of the laboratory investigation of the characteristics of the experimental reactor VVR-S undertaken with the aim of studying the neutron and physical parameters which are the most important for putting the reactor into operation and for its exploitation. As the result of the experimental work carried out, the critical mass and the maximum and operating fuel charges were found, the compensating capacity of the control and emergency rods was determined, the influence of the various factors (variation in the temperature of the water in the active zone, variations in the properties of the reflector, etc.) on the reactivity was studied, the distributions of neutron density with height and along the radius of the active zone were measured, and the operating time of the control rods was obtained.

The research reactor VVR-S with a thermal power output of 2000 kw [1] has been developed on the basis of the operating experimental enriched-uranium reactor VVR [2]. Ordinary water is used as moderator, reflector, and coolant in the reactor.

According to the latest variant of the design, the initial fuel charge of the reactor VVR-S is approximately 4 kg of U^{235}. The maximum and average thermal-neutron fluxes in the active zone are equal to approximately $2 \times 10^{18}$ and approximately $1 \times 10^{18}$ neutrons cm$^{-2}$ sec$^{-1}$.

The testing of the main design parameters and of the operation of the reactor VVR-S as a whole was carried out on a special experimental stand.** The experimental arrangement was also used to obtain the data required to put the reactor into operation, to investigate the neutron and physical parameters of the active zone, to carry out hydraulic tests, and to test the operation of the control and emergency systems. The design of the reactor was based on the experimental results obtained with the help of a simulator and during the starting-up of the reactor VVR.

Experimental Arrangement and Equipment

A general view and a schematic diagram of the experimental arrangement are given in Figs. 1 and 2. The circulation loop reproduced the primary loop of the reactor VVR-S, but without a heat exchanger and a de-aerator, and therefore had a somewhat smaller hydraulic resistance than the latter. The water was circulated by means of five centrifugal pumps, each with a discharge of approximately 340 m$^3$/hour.

The active zone of the reactor (Fig. 2, b) with cells for the reception of 52 fuel-element containers was reproduced in full on the stand. Each container (Fig. 3) held 16 fuel elements arranged in a square lattice with a step of 17 mm (the average lattice spacing in the active zone is approximately 17.5 mm; the average ratio of

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* The calculation of the neutron and physical parameters of the reactor were carried out by T. N. Zubarev.
** Constructed by a group of workers under the direction of O. I. Liubimtsev and I. V. Koptev.
the volume of water to the volume of uranium \( \frac{v_{\text{H}_2\text{O}}}{v_{\text{U}}} \approx 6.0 \). The fuel elements contained enriched uranium (up to 10%) and were in the form of rods enclosed in aluminum pipes with an external diameter of 10 mm and wall thickness 1.5 mm. The length of the working region of the fuel elements was 500 mm.

Fig. 1. General view of the experimental arrangement.

The whole of the reactor active zone was divided into three parts; the water input to each of them was set in accordance with the radial distribution of heat production by means of regulating valves. The pumps circulated water at the rate of approximately 1500 m\(^3\)/hour. However, when the reactor is operating at a power level of 2000 kw, the rate of water circulation required is 650 m\(^3\)/hour.

The temperature of the water in the active zone was measured with the help of three thermocouples.