METHOD FOR DEFINING THE CONCENTRATION OF FISSILE MATERIALS IN RADIOACTIVE WASTE

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In the work the development materials of an industrial technique definition of fission materials concentration in radioactive waste are resulted. The active analysis lays on the basis of a technique. Researched samples were irradiated with flows of neutrons received on the basis of the electron linear accelerator. Experiment was carried out on ELE - 300 NSC KIPT using neutron - making target made of Pb (5 cm in diameter and 4 cm in thickness). At an electron beam energy of 20 MeV and an average current of 1 μA such a target can produce a total neutron flux of about $2x10^{10}s^{-1}$. The achieved sensitivity by definition of concentration ^{235}U is at the level 10^6 g/g.

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For today's nuclear industry, of prime importance and urgency is the task of carrying out the analysis for the contents of fissile material (FM) in different sort radioactive waste (RW). This problem is particularly pressing for Ukraine, where the development of technologies for extraction of nuclear fuel from the destroyed ChNPP Unit 4 is supposed.

The nuclear-physical methods of FM control are widely diversified [1]. The most widespread are the methods where the samples, containing the sought-for fissile element, are activated by neutrons or γ-quanta [2–4]. Thus the concentration of sought-for elements is determined from the yield of prompt or delayed neutrons from fission reactions.

Now at NSC KIPT various lines of activation analysis are being developed to determine the isotope composition of radioactive waste.

The purpose of the present work has been the research into the possibility of carrying out a high-sensitivity analysis of low ^{235}U concentration in industrially produced radioactive waste. The samples were supposed to be activated with the help of neutron flows produced from high-current electron linear accelerator.

The experimental layout is shown in fig.1. The parameters of the LEA-300 test bench (1) are as follows: the electron beam energy can vary in the range E_0=0–30 MeV, the frequency of current pulses is in the range of f =1-100 s^{-1}, the current pulse duration is t = 1 μs, the average current can attain ~ 50 μA.

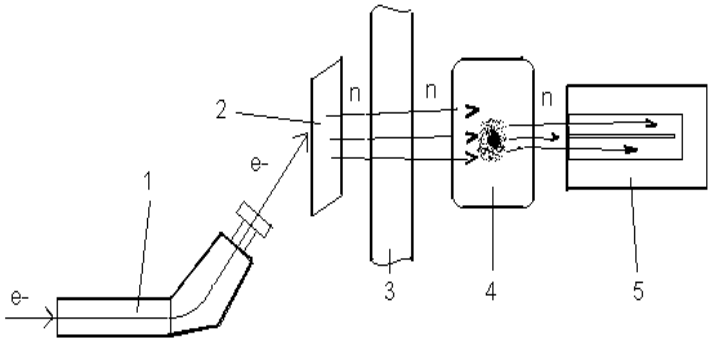

Fig. 1. *The diagram of experiment.*

An electron-irradiated lead converter (2), 5 cm in diameter and 4 cm in thickness, served as a source of neutrons. At an electron beam energy of 20 MeV and an average current of 1 μA such a target can produce a total neutron flux of about2 $x10^{10}s^{-1}$.

During the current pulse of the accelerator a neutron flux with an energy spectrum close to Maxwell distribution with an average energy ~ 1 MeV was formed in the lead converter. Then followed the moderator (3), which completely cut off the object and the inlet aperture of the detector. The basic purpose of the moderator was to form a flux of thermal neutrons and thereby to create conditions for intensive fission of ^{235}U.

The objects under study (4) represented samples of uranium having the known isotopic structure (98 % ^{238}U and 2 % ^{235}U), and surrounded by a sand mass 10 kg in weight.

The neutron detector (5), used in experiment, was made following the circuit of the all-wave detector [3],

where the counter CHM-11 with a boron substance-coated cathode was used for detection of thermal neutrons.

In experiment, the delayed neutrons were registered in the time interval of 4 – 20 ms between the current pulses of the accelerator (f=50 s^{-1}). In this interval the intensity of background readout of the detector was minimal. In this case the background readouts are those of the detector when the accelerator is in operation but with absence of uranium in the object under irradiation.

Two series of measurements with an interval of 12 hours were carried out; in each of them the weight of ^{235}U in the sample was varying from 1.1 to 0.012 g. During measurements the average current of the accelerator was invariable and equal to 2 μA, the set of statistics was performed for 410 s.

The results of measurements are given in fig. 2, from which it is seen, that under specified conditions the installation allows one to detect the presence of ^{235}U up to 0.012 g or the concentration up to 10^{-6} g/g. Besides, there is the proportionality between the yield of delayed neutrons and weight of ^{235}U that confirms reliability of measurements.

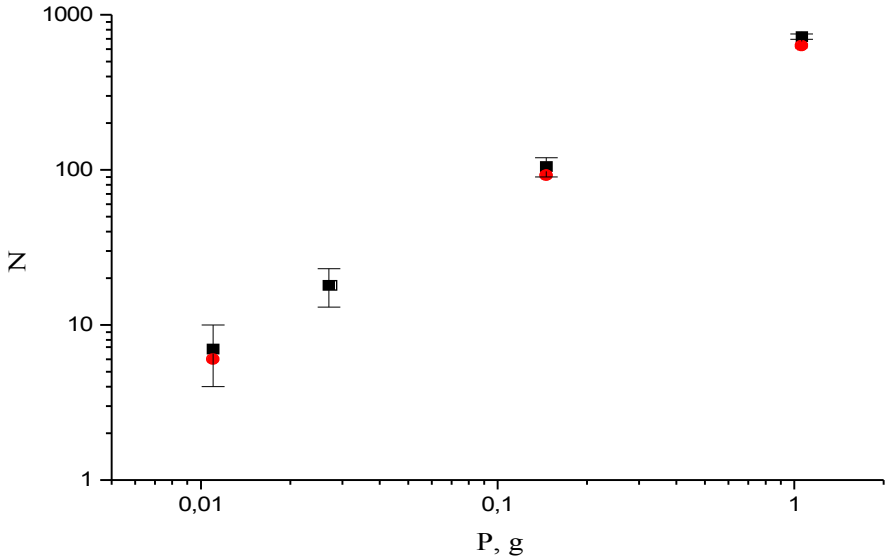

Fig. 2. *The dependence of neutrons detector indications (N) on quantity of uranium in a sample (P, g).*

For checking the absence of the contribution of delayed neutrons from ^{238}U fission the samples under investigation were wrapped up in a cadmium sheet 1 mm in thickness. The readout of the detector decreased up to a level of a background, as cadmium shielded uranium from thermal neutrons (E_n < 0,4 eV). It means, that the effect observed is caused by ^{235}U nucleus fission with thermal neutrons, because the cross-section of this process in the above mentioned energy is 10^5 - 10^6 more than the cross-section of ^{238}U fission.

The data obtained allow one to estimate the applicability of the technique and installation under consideration for working out the practical tasks related to the accident at ChNPP and to atomic engineering. The preliminary analysis shows, that the increase of installation power not exceeding the limits of real technical and economic feasibilities will allow conducting the analysis of RW-samples having a weight of hundreds kg with a limit of sensitivity to ^{235}U not worse than 10^{-7} g/g. In this case a special preparation of samples being studied is not required.

It should be noted, that the potentialities of the installation already in the present assembly are sufficient for defining the concentration of ^{235}U in nuclear fuel.

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