Savkin Alexander Evgenievich

Processing of radioactive waste with selective extraction of radionuclides and conditioning of spent sorbents

Specialty 2.6.8. - Technology of rare, scattered and radioactive elements

Abstract of the dissertation for the degree of Doctor of Technical Sciences

The successful development of the nuclear industry in the 21st century is impossible without solving the problem of radioactive waste (RW) management. In Russia, RW activity of about 2000 MCi has been accumulated. Currently, the main sources of RW formation are: spent nuclear fuel reprocessing enterprises, nuclear power plants, RW processing enterprises, research centers, radioactive waste storage facilities (RWSF). At some enterprises there are no RW processing plants, at many – the volume of conditioned RW significantly exceeds the initial one.

Within the framework of this work, the problems of RW management at these facilities are considered, with the exception of radiochemical enterprises due to the specifics of the latter and the limited information about them. The development of methods for the selective extraction of radionuclides from LRW of various chemical composition and activity levels, as well as the conditioning of ion exchange resins (IER} and other sorption materials is very relevant, because it will significantly reduce the volume of conditioning RW, increase their safety during long-term storage and reduce the cost of disposal of RW.

The aim of the work is to develop methods for the selective extraction of radionuclides during the processing of medium and low–level SRW and LRW, as well as methods for conditioning spent ion exchange resins and inorganic sorbents as the basis for creating new effective technologies for processing and conditioning LRW and SRW.

To achieve this goal , it is necessary to solve the following scientific tasks:

- to determine and systematize the main sorption-selective characteristics of various sorbents in relation to radionuclides of cesium, cobalt, manganese, etc. when sorption from high-salt LRW of different composition;

- to develop methods for the selective deposition of radionuclides of cesium, cobalt, manganese, etc. from LRW of various compositions and to determine the optimal conditions for their implementation;

- to study the effect of organic substances on the processes of sorption and co-deposition of radionuclides of cesium, cobalt, manganese, etc. from high-salt LRW;

- to develop methods of oxidative degradation of organic substances in the composition of high-salt LRW followed by the release of radionuclides of cesium, cobalt, manganese, etc. sorption or precipitation methods;

- to develop methods for processing salt melts accumulated at Russian nuclear power plants;

- to study the possibility of using selective sorption of radium radionuclides and other daughter products of uranium decay from low-salt LRW for processing and conditioning of accumulated LRW in RWSF;

- to develop methods for the selective extraction of radionuclides from secondary LRW formed during vitrification of high-salt LRW and thermal processing of SRW, as well as from solutions after decontamination of metallic radioactive waste;

- to develop methods for conditioning spent ion exchange resins and inorganic sorbents using a polymer binder;

- to carry out a technical and economic assessment of the developed methods of processing LRW of various chemical composition and activity level and conditioning of spent IER and inorganic sorbents.

Scientific novelty of the work:

For the first time, the sorption-selective characteristics of various sorbents have been quantified during the sorption of cesium radionuclides from high-salt LRW containing organic complexing substances;

methods of selective deposition of radionuclides of cesium, cobalt, manganese, etc. from high-salt LRW have been developed and optimal conditions for their implementation have been determined;

the influence of organic substances on the processes of sorption and co-deposition of radionuclides of cesium, cobalt, manganese, etc. from high-salt LRW has been studied for the first time;

the process of oxidative degradation of organic substances in high-salt LRW by ozonation has been studied;

for the first time, the mechanism of the negative effect of chromate ions on the extraction of cobalt radionuclides from the evaporate concentrate (EC) of nuclear power plants has been studied and a method for eliminating this effect has been proposed;

methods of processing salt melts of nuclear power plants using selective extraction of radionuclides have been investigated and the main technological parameters of their implementation have been determined;

the swelling of dried ion exchange resins was studied for the first time and the swelling pressure was measured;

the process of conditioning spent ion exchange resins by inclusion in a polymer compound based on epoxy resins directly in a container for disposal has been studied and the main technological parameters have been determined.

Practical significance of the work

The conducted research formed the basis of a number of technologies for processing various medium and low-level radioactive waste. Successful laboratory, bench, pilot-industrial and commissioning tests of the developed technologies for the processing of LRW of FSUE "RADON", LRW of the SSC RF FEI, LRW and SRW of nuclear power plants of Russia and Kazakhstan were carried out.

A technology has been developed for the processing of LRW of the SSC RF FEI using selective sorption of cesium radionuclides during cementation, which made it possible to carry out the process with a single-zone layout of equipment and reduce the volume of conditioned RW by replacing the containers of NZK with KMZ.

The technology of oxidation-sorption purification of EC of nuclear power plants has been developed, which made it possible to achieve a reduction factor of 80-100 in the volume of radioactive waste.

The technology of ultrasonic decontamination of metallic radioactive waste with selective extraction of radionuclides from washing water has been developed, which has significantly reduced the volume of secondary radioactive waste.

The technology of selective purification of LRW from radium and daughter products of uranium decay has been developed, which reduced the formation of conditioned radioactive waste by 4-5 times compared with the precipitation technology of purification of LRW from radionuclides.

The developed technology of conditioning spent ion exchange resins directly in the container for disposal by dehydration and incorporation into a polymer compound allowed to obtain a final product that meets the requirements of NP-019 and NP-093 in a volume 4-5 times smaller than during cementation.

A method for determining the swelling pressure of dried IER has been developed, which made it possible to establish the possibility of destroying the integrity of the container during the disposal of dried IER.

The following are submitted for protection:

a set of experimental results to determine the sorption-selective characteristics of various sorption materials for the extraction of cesium radionuclides from high-salt LRW;

methods of selective deposition of radionuclides of cesium, cobalt, manganese, etc. from high-salt LRW and determination of optimal conditions for their conduction;

results on the study of the effect of organic substances and chromate ions on the processes of sorption of cesium radionuclides and co-deposition of cesium radionuclides, cobalt, manganese, etc. from high-salt LRW;

results of the study of methods of oxidative degradation of organic substances in the high-salt LRW with subsequent release of radionuclides of cesium, cobalt, manganese, etc. sorption or precipitation methods;

test results of bench, pilot and industrial plants for processing EC of nuclear power plants;

results of laboratory, bench and pilot-industrial tests of technologies of processing of LRW of FSUE "RADON", LRW of SSC RF FEI, RWSF (Saakadze, Georgia);

results of the development of methods for processing secondary LRW formed during thermal processing of SRW and decontamination of metal radioactive waste;

results of conditioning of spent ion exchange resins and inorganic sorbents by inclusion in a polymer compound based on epoxy resins;

technical and economic assessment of the developed methods of processing of LRW and SRW of various chemical composition and activity level.