SAFETY EVALUATION OF NON-REACTOR TECHNOLOGIES OF CLOSED NUCLEAR FUEL CYCLE: CHALLENGES AND CODE SYSTEM

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One of the most important challenges in creation of radiochemical production is to ensure nuclear, radiation, and technological safety of all facilities of an enterprise. Currently, safety of technological processes in radiochemical production is mainly supported by special experiments that simulate the conditions of technological processes, or based on the operating experience of similar production facilities. This approach takes a lot of time and resources to conduct the necessary experiments, which makes it quite demanding. In addition, the inability to experimentally model a lot of emergency situations, especially for newly developed processes that have no analogues as well as the involvement of high-active materials in the nuclear fuel cycle (NFC), that is typical for the developed technologies of the closed nuclear fuel cycle (CNFC), makes this approach very constrained or even unfeasible.

Mathematical modelling is another possible way to justify safety, but at present verified and certified codes for the processes of the non-reactor part of the fuel cycle are hardly available. Within the project Proryv, models and codes for simulating CNFC technological processes have been developed. They can be used as a base for the design-basis justification of NFC technological process safety.

Currently, a system of models and codes is being developed, that will be used to justify CNFC technological process safety, integrated simulation, and optimization of CNFC parameters and layouts of technologies and production facilities. It includes both models and software tools for simulating CNFC technological processes and apparatus as well as special program complexes designed to evaluate various hazards that are typical for radiochemical production. Among them are the program complex VISART [1] designed to calculate the characteristics of CNFC material flows, including nuclide compositions and, accordingly, the activities and heat release of operation environments, models of CNFC technological processes [2], and a program complex for modelling heat and mass transfer in the multicomponent chemically reacting media. To evaluate safety criteria, special program complexes designed to calculate critical and radiation properties of materials are used as well as the program complex FIREX [3] designed to evaluate fire and explosion safety of CNFC technological processes, in which calculation methods for various types of ignition of reaction mixtures, developed by the Scientific and Engineering Center for Nuclear and Radiation Safety (FBE "SEC NRS") are implemented.

The developed code system was used to evaluate the dose load on the extractant, the yield of radiolytic hydrogen in dissolution and fractionation operations, and other tasks. The paper presents an overview of the developed models, analysis of their applications, and formulates proposals on further development of these works.

References

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