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HLW evaporation technology which includes decomposition of bottom solution components using reductants as applied to the highly burnt-up spent nuclear fuel reprocessing

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Introduction

Evaporation of tail solutions from spent nuclear fuel reprocessing is a required activity before high-level waste (HLW) solidification. Evaporation of HLW according to the traditional flow sheets of the 2nd generation reprocessing plants is complicated by an increase of the sediment-forming fission products amount due to a 100-fold increase in SNF burnup, as well as the presence of fluoride ion in raffinates.

Decomposition of bottom solution components using reductants during evaporation

To solve the problems of precipitation, a process of highly active raffinate evaporation with continuous decomposition of nitric acid was developed and laboratory testing in the evaporator with external heating chamber and natural circulation of bottoms was carried out. The decomposition of nitric acid during evaporation was carried out when a solution containing a reductant is supplied to the evaporator bottom part, the process was carried out when the solution is retained in the bottom part. Mixture of formaldehyde and formic acid was used as a reducing agent, or a solution of formic acid is used after the start of the process using a mixture of formaldehyde and formic acid. The composition of the denitrating reagent was determined, which ensures the minimization of N₂O formation during the evaporation process with simultaneous denitration.

A technological flow sheet was developed for HLW concentrating with the purification of nitric acid from fluoride ion at the rectification stage by distillation into the vapor phase and localization at the alkaline absorption stage. The main results on the HLW model solutions evaporation with denitration achieved at the laboratory bench were reproduced at the SverdNIKhimmash JSC full-scale bench facility. As a result of distillation purification, regenerated nitric acid with the concentration of 11 to 12 mol/L and with its purification from fluoride ion from 6 to 7.5 times was obtained.

Verification of a previously developed mathematical model of rectification with purification of nitric acid from hydrofluoric acid was also carried out. The data obtained as a result of a bench test formed the basis for creating a mathematical model of the process for the evaporation of HLW with the continuous decomposition of nitric acid.

Conclusion

HLW evaporation technology which includes decomposition of bottom solution components using reductants as applied to the highly burnt-up spent nuclear fuel reprocessing was successfully developed and tested at the SverdNIKhimmash JSC full-scale bench facility.

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