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Physical feasibility of MA transmutation in a two-component nuclear energy system in Russia

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The transition to a two-component nuclear power structure using thermal (TR) and fast reactors (FR), as asserted by the «Russian nuclear power development strategy to 2050 and outlook to 2100» (Strategy-2018), is directed at finding optimal solutions and resolving relevant issues pertaining to the currently established nuclear energy system in Russia. A core issue in this regard is managing the long-lived MA inventory, which have a substantial impact on overall nuclear power radiological safety for time-frames that could be considered historically significant. The study presents findings related to analyzing the capability of a commercial fleet of FRs to successfully resolve these issues by including MA in the closed nuclear fuel cycle without any fundamental changes to their expected characteristics regarding safety and competitiveness parameters.
Three different Russian scenarios were considered in the study: 1) full transition to a large-scale FR dominated nuclear fleet reaching 92 GWe capacity by the end of the 21st century, 2) mixed composition of VVER (43% capacity) and FR (57% capacity) with comparable installed capacity 3) a moderate nuclear power development scenario reaching 72 GWe by the end of the century with a 57% VVER and 43% FR mix. At this rate it is calculated that 36-67 tonnes ofAm and 67-120 tonnes of MA (Am+Np) would be accumulated from the VVER fleet.
Two algorithms are proposed for Am and Np utilization. In the first approach, MA and Pu obtained from reprocessing VVER spent fuel are simultaneously used for FR start-up, after which the fuel will reach an equilibrium state following multiple recycling in the fast reactor. The maximum concentration of MA content in the fuel was calculated to be at 2% (1,1% Am and 0,9% Np), and 0,5% when the fuel reaches equilibrium state.
If radiation-related limiting factors for handing nuclear fuel with high MA content are taken into account, comparable MA utilization efficiency could be achieved with lower MA fuel concentration if they are introduced evenly throughout the FR operation lifecycle. Continuous addition of MA from VVER reactors to FR fuel with 2% MA concentration will increase MA utilization threefold compared to the first approach.
The results of the study conclude that the MA arising from VVER spent fuel accumulation in all scenarios considered could be successfully utilized without dedicated MA-burners, although the complexity of the issue intensifies as fewer FRs are introduced into the power mix with increased MA content in their fuel.

Country/Int. organization

Russian Federation

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