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Study on the sensitivity analysis of the installed capacity and the high-level waste generation based on closed nuclear fuel cycle

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The sustainable development of nuclear energy calls for the maximization of uranium utilization and, meanwhile, the minimization of the waste produced. The fuel cycle mode and its key parameters have a great influence to the deployment of nuclear energy and the generation of high-level waste. In this paper, a sensitivity analysis is made on the influence of out-of-core residence time and the recovery ratio of the actinides; a series of recommended value are given to the parameters mentioned above; the effect of the closed fuel cycle on the reduction of high-level waste is analyzed. The following conclusions are drawn: 1) in the multi-cycle of industrial Pu or transuranics(TRU) in fast reactors, the contents will reach an equilibrium state; in typical SFR, the fissile Pu takes an fraction of 70% in the equilibrium state, and the minor actinides(Mas) take an fraction of 3% in the TRU recycle; 2) the installed capacity of fast reactor is very sensitive to the out-of-core residence time and recovery ratio; the generation of high-level waste is sensitive to the recovery ratio; the recommendation is the out-of-core residence time be no more than 5 years and the recovery ratio of actinides be no less than 99.9%; the reasons are that in order to avoid the decreasing of the nuclear installed capacity during the transition from PWRs to FRs, and that in order to reduce the recycling loss and decrease the generation of the waste, the recovery ratio is proposed to be no less than 99.9%; the benefit of further improvement of the ratio beyond 99.9% is insignificant either for the installed capacity or for the high-level waste; 3) the synergistic development of the PWRs and FRs in closed fuel cycle can not only improve the utilization of uranium but also effectively reduce the generation of the high-level waste; compared with the once-through method in PWRs, closed-fuel-cycle can reduce the long-term radioactive toxicity of high-level waste to 1/5˜1/6 with a recovery ratio of 99.9%; the TRU whole cycle can effectively reduce the amount of MAs and further reduce the long-term radioactive toxicity of high-level waste to 1/7˜1/8.

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