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Design Strategies for Direct Recycling of ACR-700 Spent Fuel

Increasing the nuclear fuel burnup has a particular importance to improve the uranium utilization, to reduce the high level nuclear waste and to reduce the amount of plutonium in spent fuel per unit energy which improves the plutonium proliferation resistance.
This work is focused on strategies for direct recycling of 700 MWe Advanced CANDU Reactor (ACR-700) spent fuel in CANDU-6 reactor. ACR-700 discharges the fuel with a significant amount of fissile isotopes (U-235, Pu-239 and Pu-241). Three strategies are considered for recycling the spent fuel of ACR-700. First strategy is recycling the ACR-700 spent fuel bundles directly in CANDU-6, since the two reactors have the same inner diameter of the fuel channel. Second strategy is removing the central pin (which has residual reactivity plenty of the Dysprosium fissionable poisons) from the ACR-700 spent fuel and re-fabricating the spent fuel bundle into CANDU-6 fuel bundles using dry processing such as the DUPIC fuel cycle. Third strategy is removing the outer fuel pins (which have the fewer amounts of fissile isotopes) and the central pin and re-fabricating the rest two fuel rings into CANDU-6 fuel bundles using the dry processing.
The calculations using the MCNPX code showed that the recycled spent fuel in CANDU-6 gives burnup around 3, 6.75 and 13.3 MWd/kgU for the three strategies, respectively. Normalizing the burnup on the all fuel in the spent bundle, additional burnup of 3, 6.5 and 6.9 MWd/kgU can be obtained for the three strategies respectively. This means that the third strategy gives the higher burnup from the spent fuel. Moreover in the third strategy, only half of the spent fuel bundle is re-fabricated into CANDU-6 fuel bundle which decreases the cost of re-fabrication. Knowing that ACR-700 burns fuel to 20.5 MWd/kgU, the third strategy can increase the burnup of fuel by about 34%. The calculations give acceptable power distributions on the fuel bundles for the three strategies and acceptable coolant void reactivity compared to reference CANDU-6.

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