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Effective use of U-234 in Thorium fuel cycle

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The Th fuel cycle is attracting interest again globally because of its advantages over the current Pu fuel cycle, such as breeding fissile 233U from fertile 232Th without using a fast reactor, lower minor actinide production and higher Pu burning. However, there are some concerns, such as the small critical mass of the bred 233U. Using 234U, which is not considered an important isotope, may overcome some problems with the Th fuel cycle. In this study, the effect and roles of 234U in the Th fuel cycle were surveyed from the perspectives of proliferation resistance (PR), fuel burn-up, and breeding in single and multiple cycles. Increasing the 234U isotope ratio increases bare critical mass, which in turn increases PR by increasing the heat generation and radiation dose rate from 232U and their daughter nuclei. The effects of the moderator-to-fuel ratio, neutron energy spectrum, and neutron flux (linear power density) on criticality were estimated. 234U was fissile in the faster neutron energy spectrum, which can increase the fuel burn-up under some conditions. A higher fuel burn-up is preferable to increase the 234U isotopic ratio. For multiple cycles, the breeding ability of 234U was higher with a softer neutron energy spectrum (33.3% at the end of the fifth cycle), but the mass balance was worse. When 234U was used with a harder neutron energy spectrum, the 234U isotopic ratio was as high as 23.6%, but the mass balance was better. The role of 234U in Th has not been thoroughly investigated until now, but this study has revealed the importance of 234U, which may lead to the development of a new Th fuel cycle.

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