



Contribution ID: 30

Type: Poster

Effective use of U-234 in Thorium fuel cycle

Thursday, 27 June 2019 10:45 (15 minutes)

The Th fuel cycle is attracting interest again globally because of its advantages over the current Pu fuel cycle, such as breeding fissile ^{233}U from fertile ^{232}Th 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 ^{233}U . Using ^{234}U , which is not considered an important isotope, may overcome some problems with the Th fuel cycle. In this study, the effect and roles of ^{234}U 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 ^{234}U isotope ratio increases bare critical mass, which in turn increases PR by increasing the heat generation and radiation dose rate from ^{232}U 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. ^{234}U 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 ^{234}U isotopic ratio. For multiple cycles, the breeding ability of ^{234}U was higher with a softer neutron energy spectrum (33.3% at the end of the fifth cycle), but the mass balance was worse. When ^{234}U was used with a harder neutron energy spectrum, the ^{234}U isotopic ratio was as high as 23.6%, but the mass balance was better. The role of ^{234}U in Th has not been thoroughly investigated until now, but this study has revealed the importance of ^{234}U , which may lead to the development of a new Th fuel cycle.

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Session Classification: Track 5 Poster Session

Track Classification: Track 5: Impacts of advanced nuclear energy systems on the back-end of the fuel cycle