ANALYSIS OF NEUTRONIC PERFORMANE FOR SMART REACTOR WITH URANIUM NITRIDE AND THORIUM FUEL

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Abstract

Maximizing the life cycle of fuel inside the reactor core has an important economic factor. It reduces the volume of spent fuel and spent fuel storage pools inside the reactor. In this paper, Uranium nitride and Thorium fuels in addition to traditional UO_2 fuel were used to increase the fuel cycle residence time inside the SMART reactor. A model of the reactor core has been designed by using MCNPX Computer code package. The multiplication factor was calculated over the fuel cycle residence period. The results showed that uranium nitride and thorium mixed with ^{233}U of the same fuel enrichment gives a higher fuel cycle length than uranium oxide. The breeding capabilities were compared between different types of fuel that have been used. The isotopes produced as a result of burning and irradiating the fuel inside the reactor core are calculated.

Introduction

SMART reactor is a typical small modular reactor , which is developed by Korea Atomic Energy Research Institute. The reactors produces 330 MW thermal energy in a dual purpose conditions which can be used for Electricity generation and water desalination. The modular design of the reactor enable the primary circuit (Steam generators , pumps , self pressurizer) to be integrated within a single pressure vessel. This design reduces or minimizes the occurrences of small or Large loss of coolant accident.

In the present paper MCNPX code is used to model SMART reactor core and four types of fuel are assumed for the reactor core UN (Uranium Nitride) , Uranium Nitride mixed with Zirconium oxide (ZrO_2) , and Thorium mixed with ^{233}U , as well as its traditional fuel UO_2. Reactor parameters are calculated and compared between all four fuel types, such as reactor multiplication factor (K_{eff}) , cycle length , discharge burn up , ^{235}U burn up (or ^{233}U for thorium case) and Pu isotopes build up. In the following , Section II Reactor data and analysis , Section III contains Computational Model , Section VI Results and discussions. Conclusion and Reference are given at the end of the paper.

3 COMPUTER MODEL

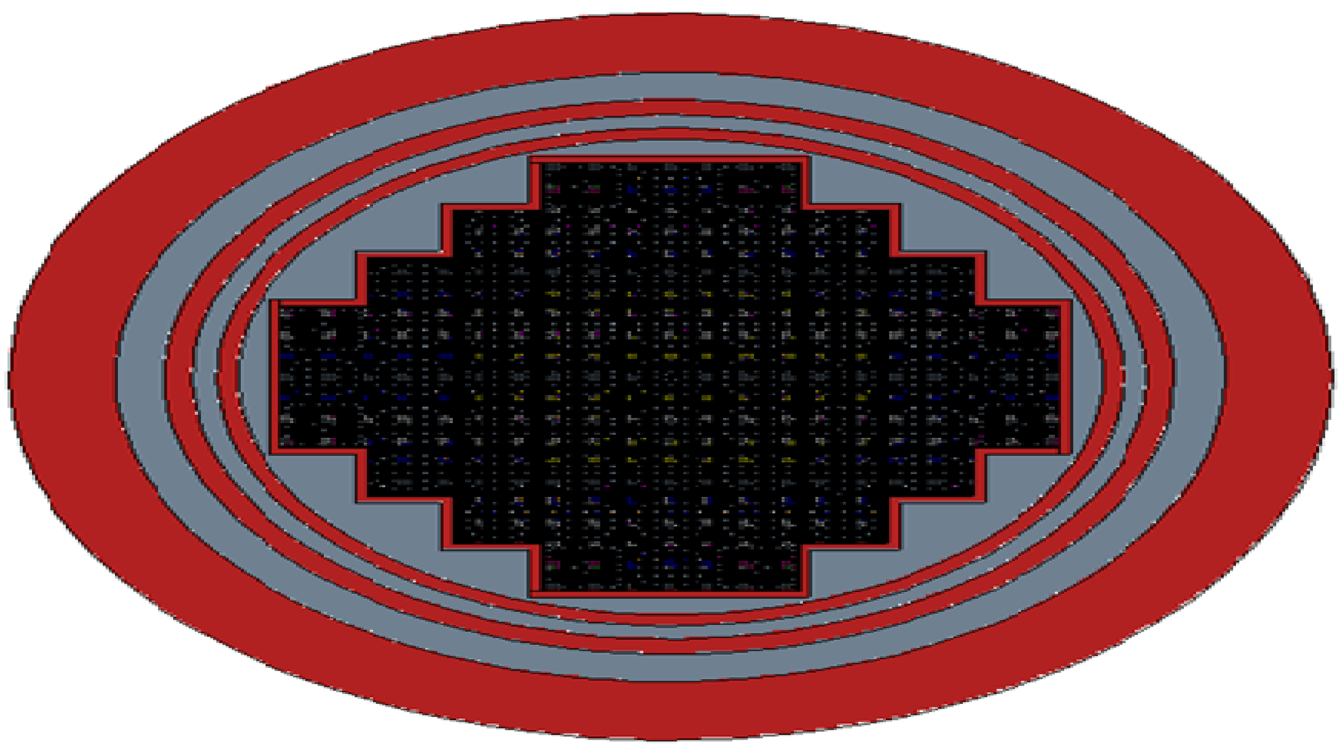

FIG (4.d) Code Model for the reactor core

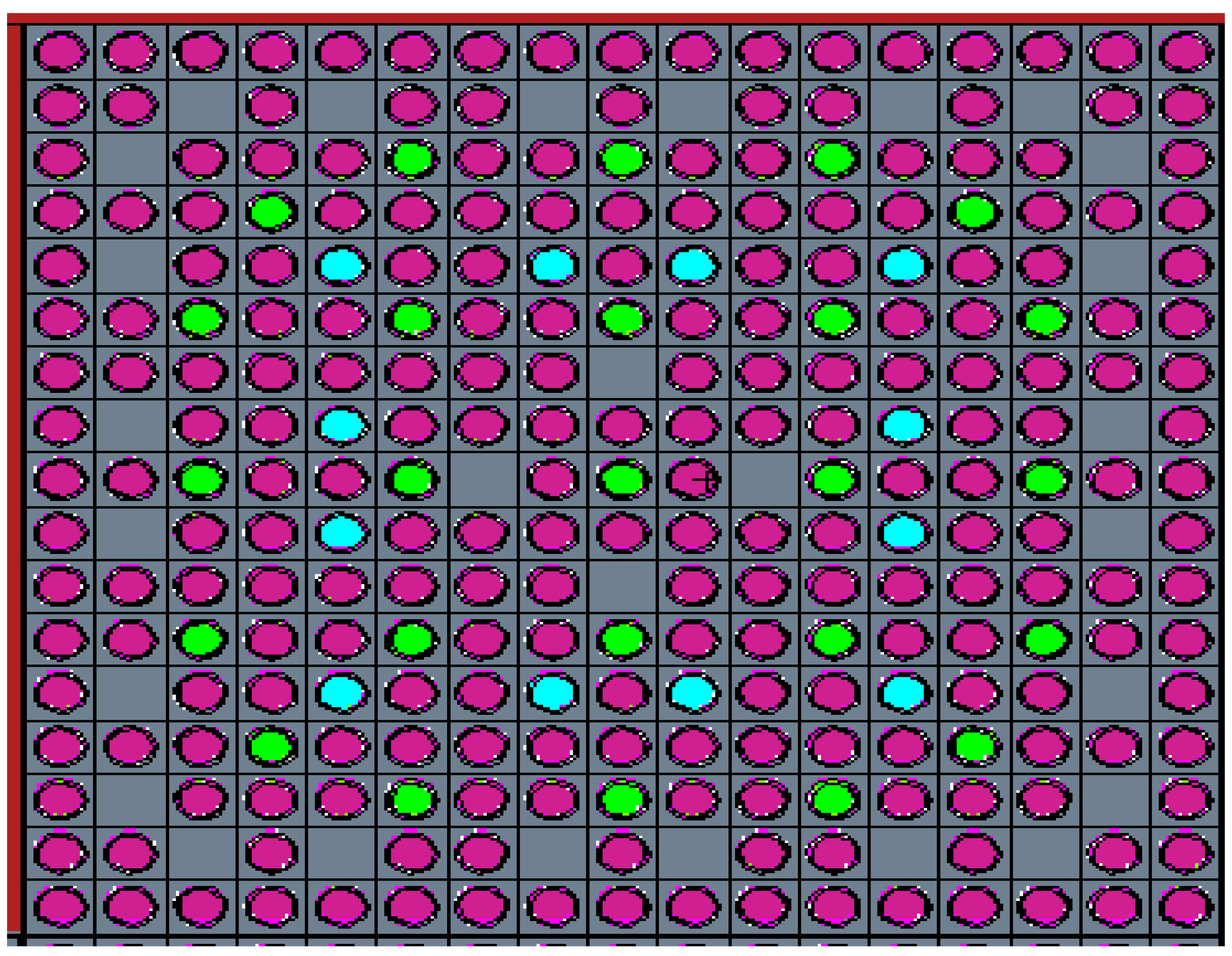

FIG (3.a)Type A MCNPX Model

Results and Discussions

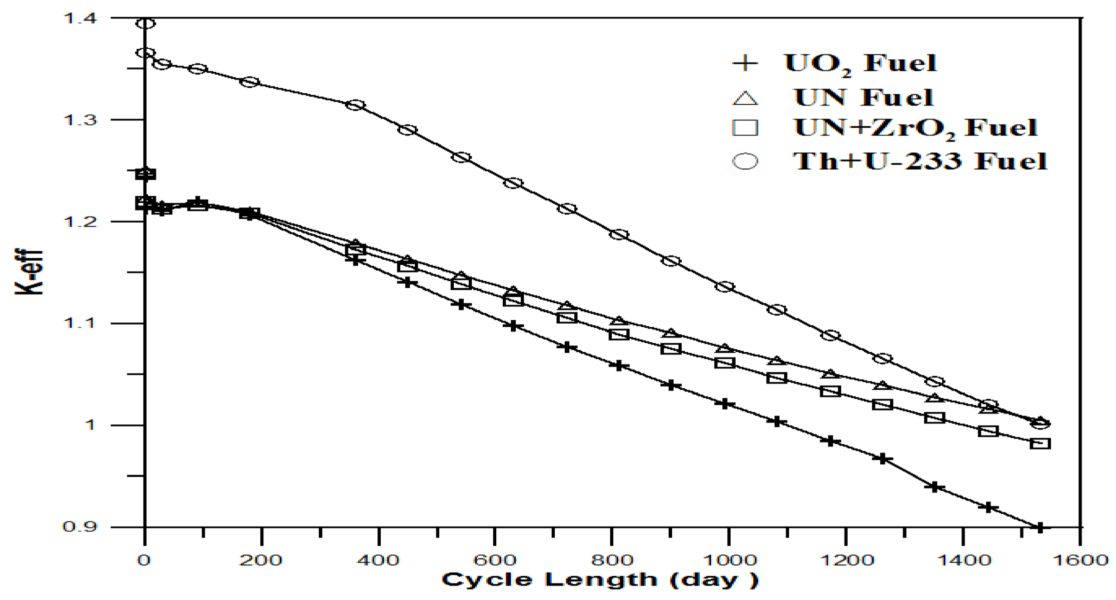

FIG 4 K_{eff} versus operation time (day) for different fuel types in the reactor core

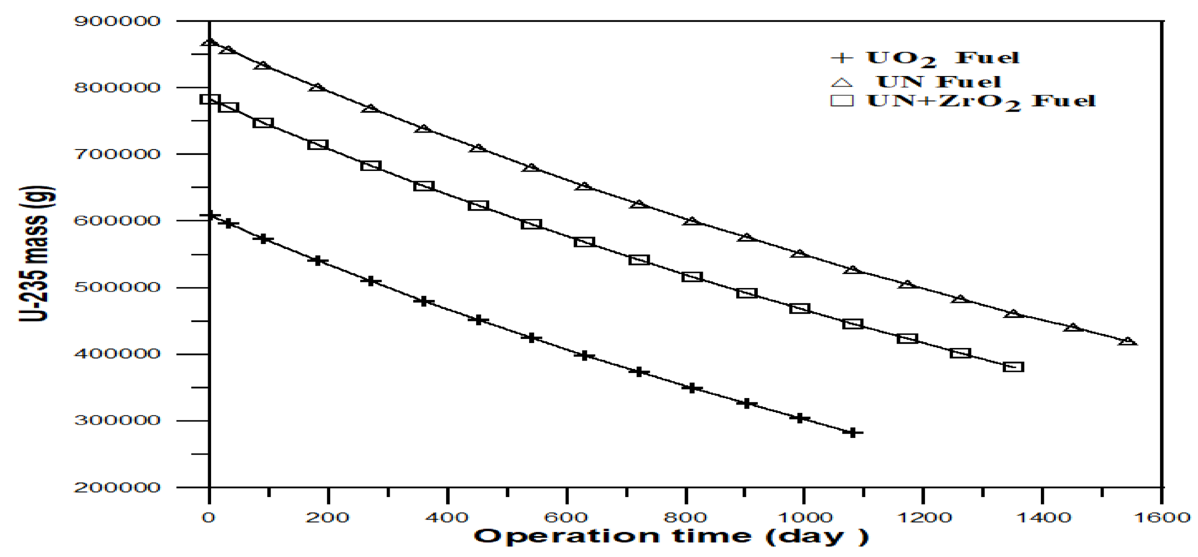

FIG. 6 ^{235}U (atom/barn. cm) versus operation time (days) for the reactor core

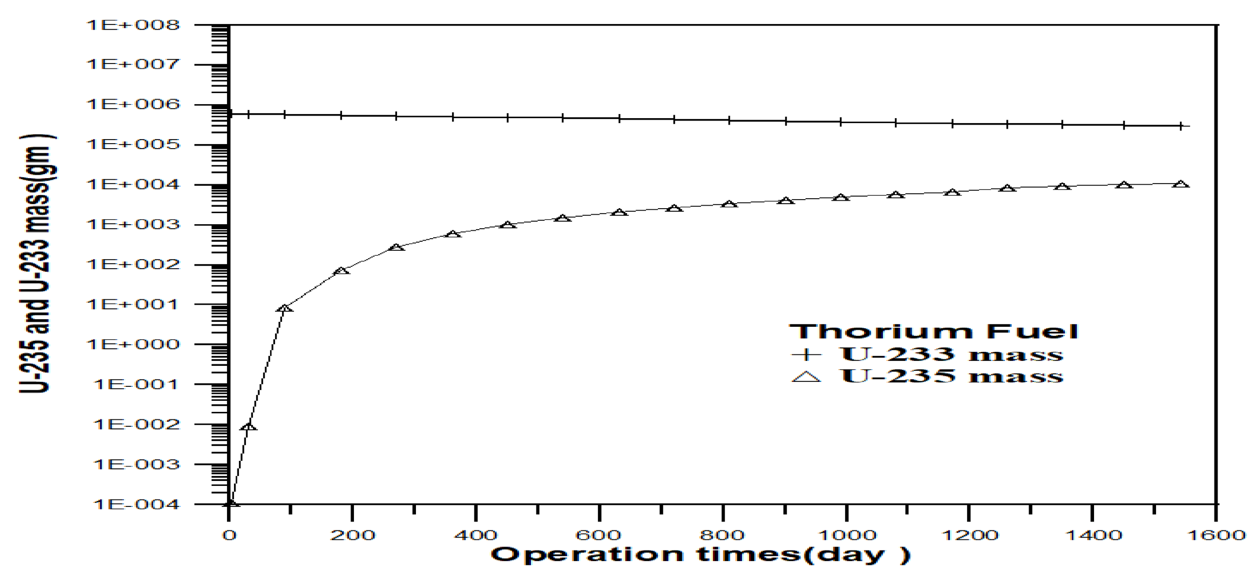

FIG. 7 Fissile isotopes (gm) versus operation time (days) for Thorium Fuel

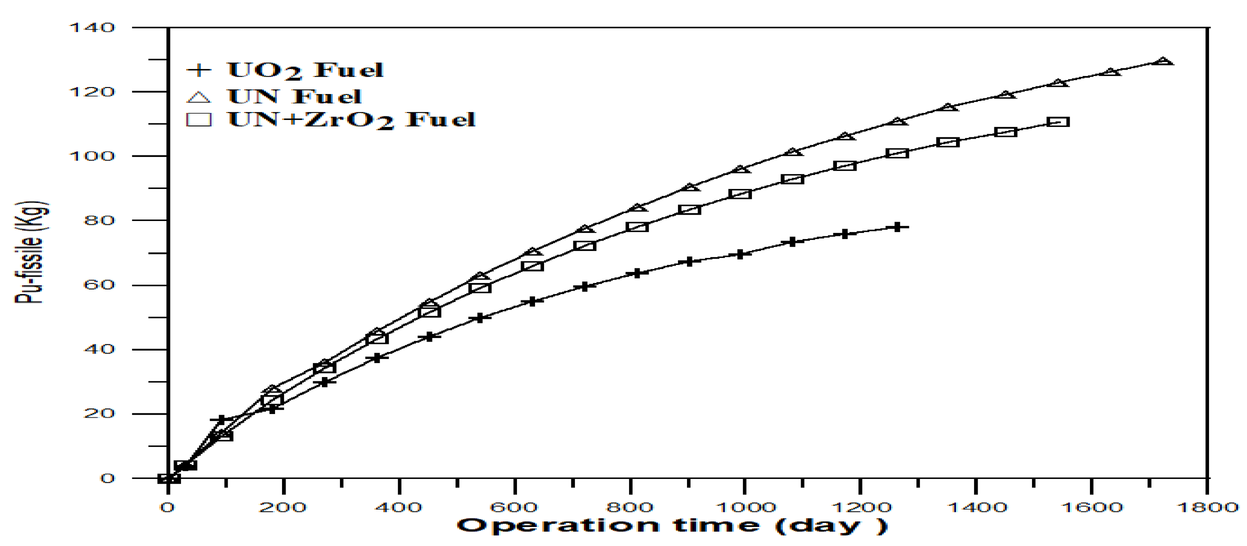

FIG. 8 Plutonium fissile isotopes (Kg) versus operation time (day)

5 CONCLUSION

- MCNPX computer Code is used to model SMART Reactor core , four types of fuel are tested in the reactor , namely UO_2 , UN , UN+ZrO_2 and Thorium fuel. The results indicate that Thorium mixed with ^{233}U and UN achieve the highest fuel cycle (1540 days) in comparison to the typical UO_2 fuel (1080 days).
- Thorium mixed with ^{233}U achieves the highest fuel burn up 39.1 MWd/T.
- UN has higher conversion ratio to ^{239}Pu , while Thorium fuel has negligible Plutonium isotopes which complies with safeguard regulations.