Optimization of initial fuel composition for Small Pebble Bed Reactor with Accumulative Fuel Loading Scheme

(2) Use of Burnable Poison

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Neutronic analysis was performed for Small PBR-110MWt with accumulative fuel loading scheme. The optimum fuel composition was obtained using 4 g HM of uranium per pebble with 20% of ^{235}U enrichment. However, significant excess reactivity occurred in the BOL condition. In the previous work, excess reactivity was reduced by using low enriched uranium. Nevertheless, burnup performance and operation period became shorter. In current study, excess reactivity was reduced by introducing burnup poision (Gd_2O_3 and B_4C) at the initial condition.

Keywords: Pebble bed reactor, accumulative fuel loading scheme, burnup analysis, burnable poison.

1. Introduction

Pebble Bed Reactor (PBR) is one of the candidates for the future nuclear power plant. In this study, PBR with accumulative fuel loading scheme was introduced. At the startup the reactor starts with a large cavity in the core, and pebble ball fuel is loaded continuously little by little until the pebble ball reach the top of the core. In this study, high excess reactivity occurred in the beginning-of-life (BOL) condition. In previous work, low enriched uranium in the BOL condition was introduced to suppress the reactivity. However, the burnup performance and core lifetime became shorter. In this study, excess reactivity in the BOL condition will be reduced by introducing the burnable poison (Gd_2O_3 and B_4C).

2. Calculation Method

In this study, MVP/MVP-BURN [1] and JENDL-4.0 were used for burnup calculation. A new code based on Fortran Languge has been developed to treat the accumulative fuel loading scheme [2]. Specification of reactor parameter is shown in Table 1. Initial core height was set to 260 cm to accommodate the average power density of 6W/cm^3. Fresh fuel will be added into the core with a stepwise procedure and the calculation will be finished after the fresh fuel reach the top of the core.

Table 1. Specification of reactor geometry

Parameter	Value
Reactor Power (MWt)	110
Core Radius (cm)	150
Core Height (cm)	1000
Reflector thickness (cm)	100
Diameter of pebble ball (cm)	6
Diameter of fuel kernel (μm)	600
TRISO layer	Buffer/I-PyC/SiC/O-PyC
Thickness (μm)	60/30/25/45

3. Results

In this study, the optimum fuel composition was achieved using 4 g HM uranium per pebble with 20% ^{235}U enrichment, the core lifetime can be maintained up to 6.5 years with the average burnup value at the End-of-Life (EOL) was 173 GWd/t. However, large excess reactivity occurred in the BOL condition. To suppress the excess reactivity, two types of burnable poison ($Gd_2O_3$and B_4C) were inserted into the reactor core. The result shows that excess reactivity decreased from around 30% to 7%. Nevertheless, the value of operation period and average burnup value at the EOL condition almost the same as the calculation without burnable poison.

4. Conclusion

Burnup calculation in a small PBR with an accumulative fuel loading scheme was performed. Large excess reactivity occurred in the BOL condition was successfully reduced by using two burnable poision only in the BOL condition.

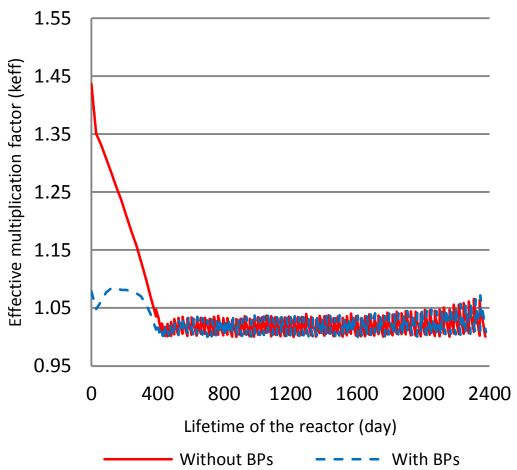

Fig 1. Effective multiplication factor of Small PBR with accumulative fuel loading scheme

References

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