Design of High Density Spent Fuel Storage Rack Applying Burnup Credit

Sanggeol Jeong[a], Wonkyeong Kim[a], Deokjung Lee[a]*

[a]Department of Nuclear Engineering, Ulsan National Institute of Science and Technology,
UNIST-gil 50, Eonyang-eup, Ulju-gun, Ulsan, 44919, Republic of Korea

*Corresponding author: deokjung@unist.ac.kr

ABSTRACT

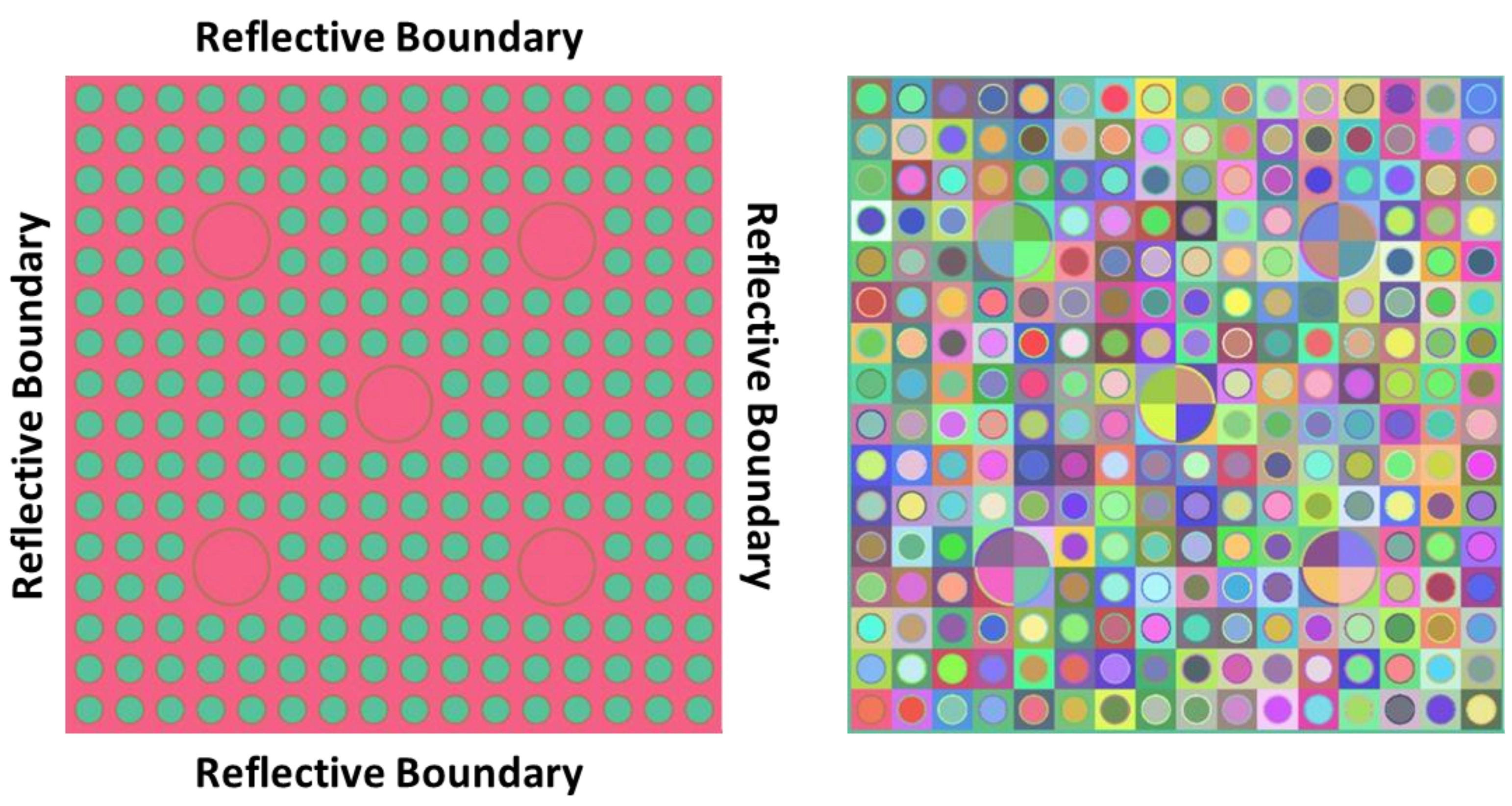
During irradiation in the reactor core, fissile nuclides composed of nuclear fuel are depleted for power generation. Usually, for criticality safety analysis, the reactivity of the spent fuel has been considered as being equal to fresh fuel. This can lead to large safety margins and thus an over-conservative design of corresponding waste management systems. In the recent past, the reduction in reactivity due to irradiation of the fuel is considered to a large extent in the design of new systems or the modification of existing systems. Taking credit for the reduced reactivity of spent nuclear fuel in criticality analyses is referred to as burnup credit. This paper presents a design of high density spent fuel storage rack applying burnup credit and annular cylinder absorber.

INTRODUCTION

- The concept of burnup credit is a taking credit to account for the decrease of reactivity due to actinide nuclides and fission products in spent fuel.
- Conventional design of neutron absorber is in form of plates located between assembly. Instead, placing the annular cylinder type of neutron absorber into the water holes of assemblies and changing the type and concentration of the material used in the neutron absorber is proposed to reduce the spacing between fuel assemblies loaded in spent fuel pool.

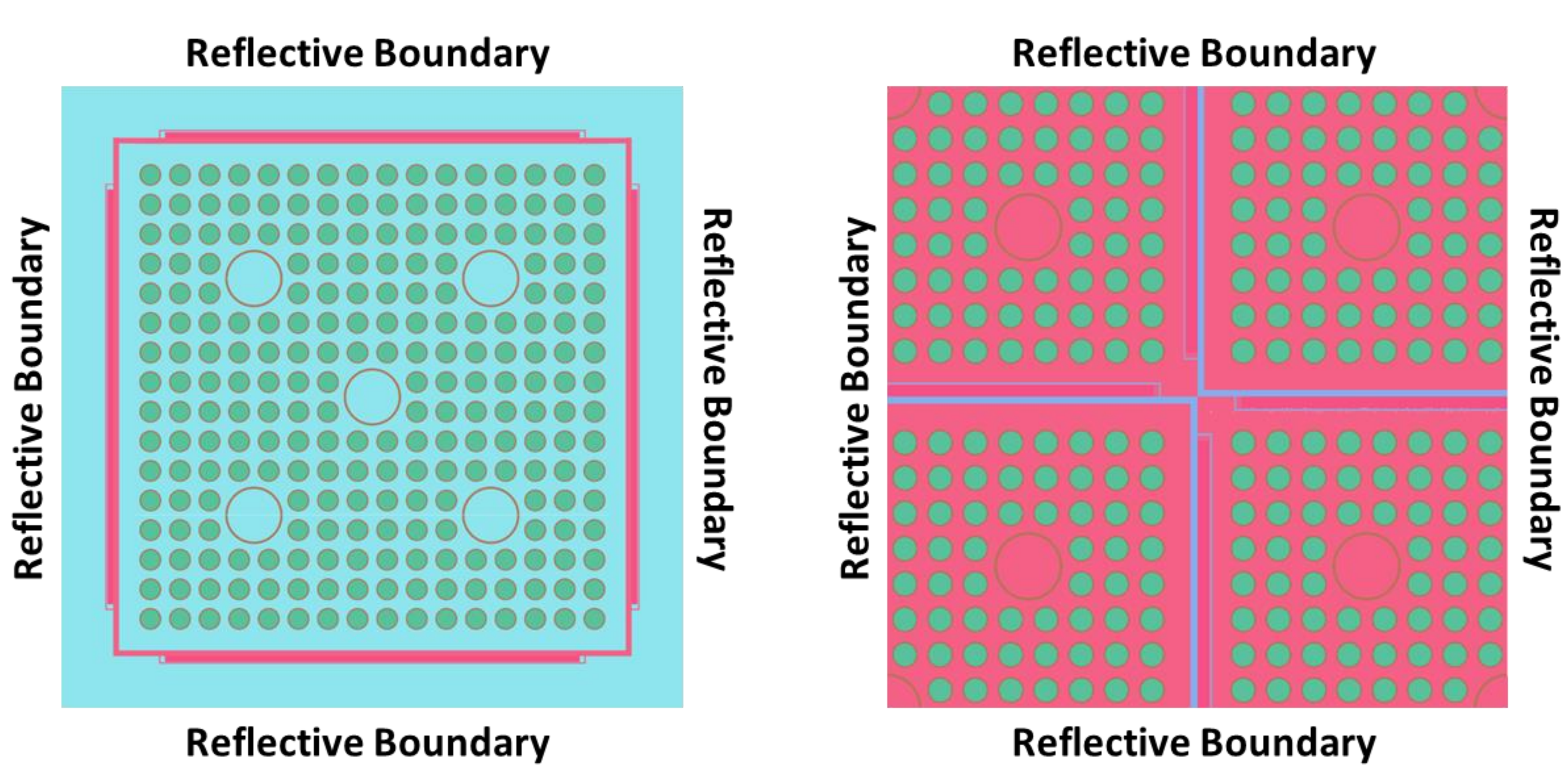
CALCULATIONAL MODEL

- **The information of depletion and criticality calculation**



XY cross plane of calculation model (MCS)

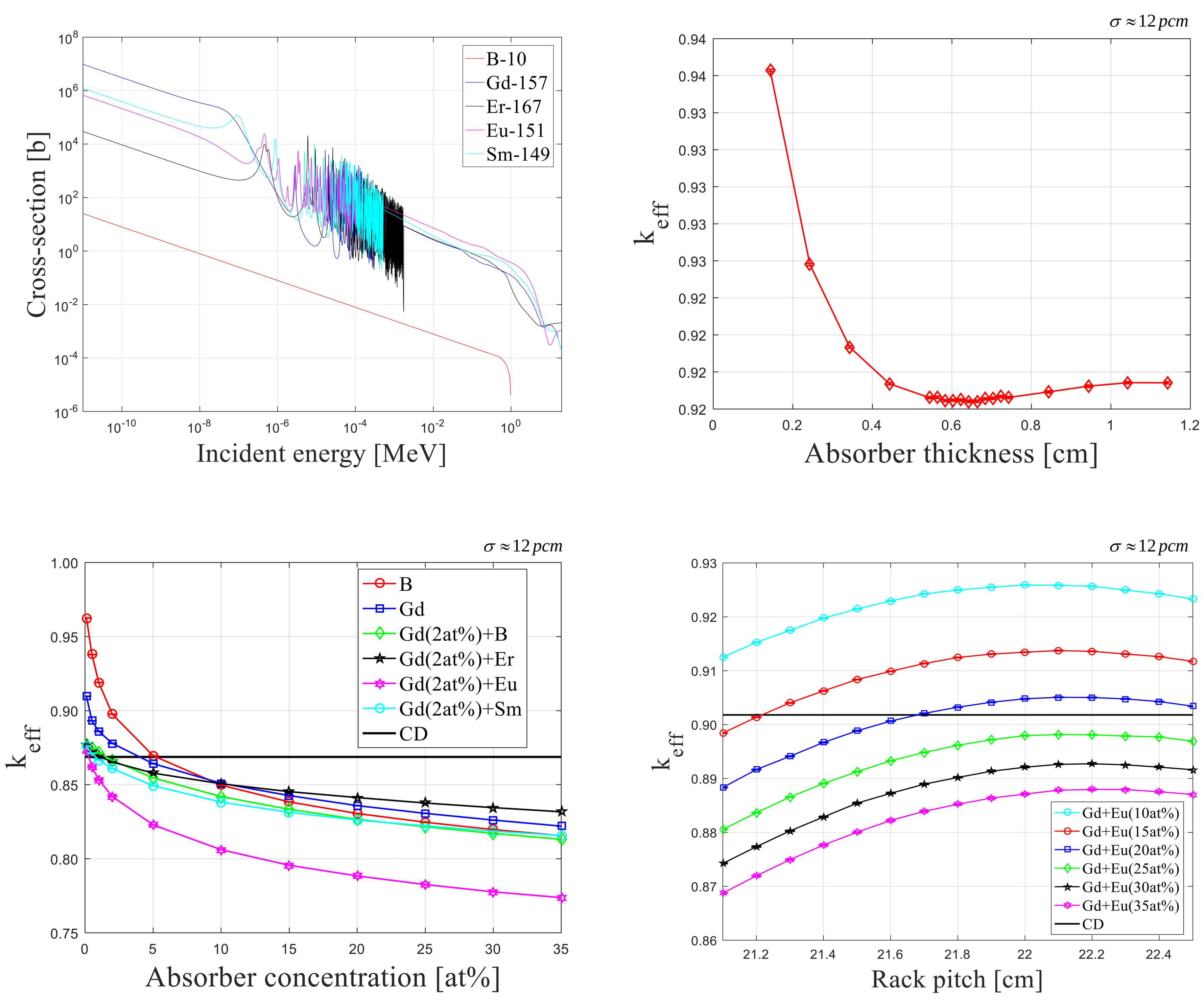
Description	
Reactor / Fuel type	APR-1400 / PLUS7
Fissionable Material	UO_2
Enrichment (wt% ^{235}U)	1.72 to 5.00
Array Size	16 x 16
Pin / Assembly Pitch (cm)	1.285 / 20.774
Moderating material	Water



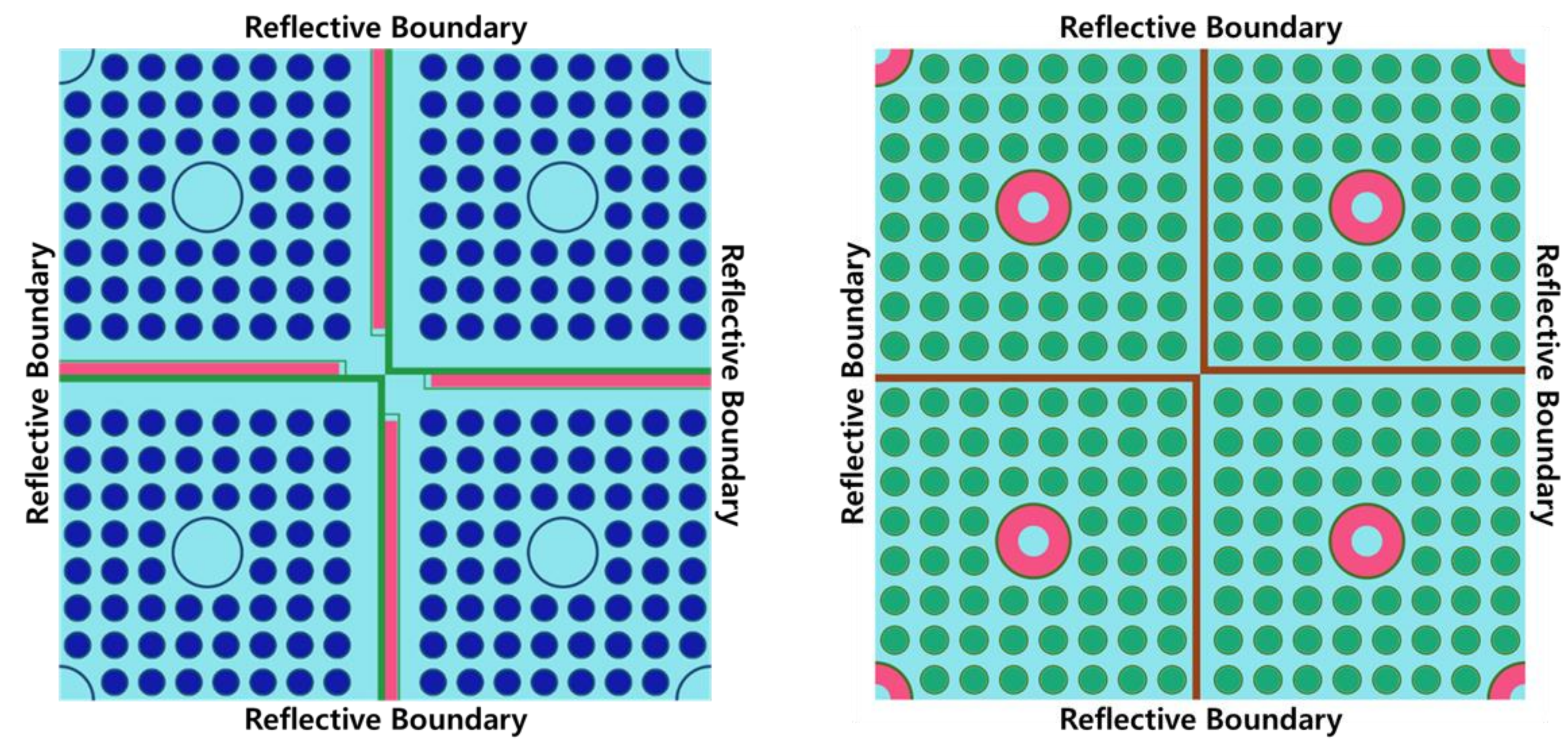
XY cross plane of Spent fuel pool, region I (left) region II (right) (MCS)

Multiplication factor (k_{eff})	Region I	Region II
MCS (Fresh Fuel)	0.69657 (1σ= 0.00012)	0.86881 (1σ= 0.00011)
MCNP6 (Fresh Fuel)	0.69620 (1σ= 0.00013)	0.86831 (1σ= 0.00013)
MCS (Depleted Fuel)	-	0.80975 (1σ= 0.00012)
Calculation time (min)	86.99 (MCNP6), 41.38(MCS)	92.58 (MCNP6), 49.38 (MCS)

SENSITIVITY STUDY ON REGION II



RESULTS



XY cross plane of conventional(left) and proposed(right) design for region II

	Conventional	Proposed
Absorber Material	Boral	Gadolinium + Europium
Absorber Concentration	-	2 at% of Gd and 15 at% of Eu
Rack Pitch (cm)	22.60	21.10

CONCLUSION

- The concept of obtaining a margin for reducing the reactivity due to nuclear fuel depletion is generally called burnup credit. When the burnup credit is applied, the number of cask can be reduced by increasing the capacity of spent fuel pool which can provide considerable financial and safety benefits
- With proposed annular cylinder type of neutron absorber instead conventional plate type of neutron absorber, the rack pitch of region II can be decreased from 22.60 to 21.10 cm while maintaining the same level of criticality safety. It can lead the 14.7% increase of spent fuel pool capacity.