Neutronic Analysis for the Effects of High-Level Radioactive Waste Distribution on Subcritical Multiplication Parameters in ADS Reactor

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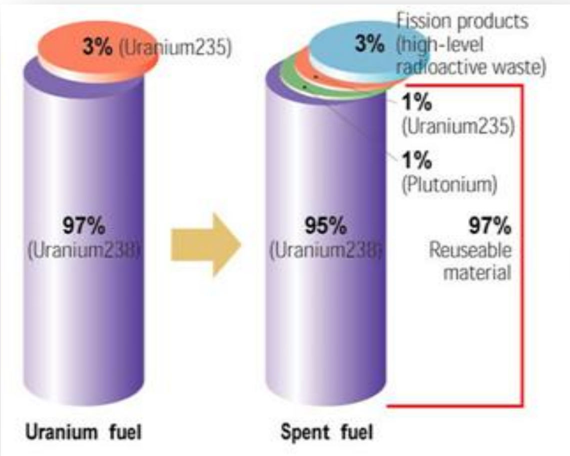
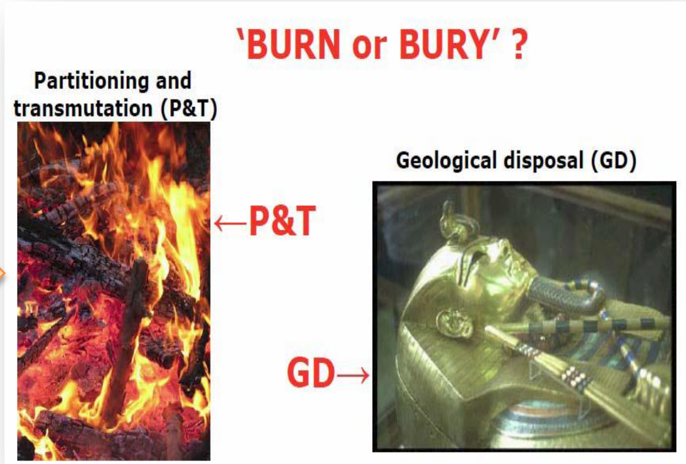
Motivation

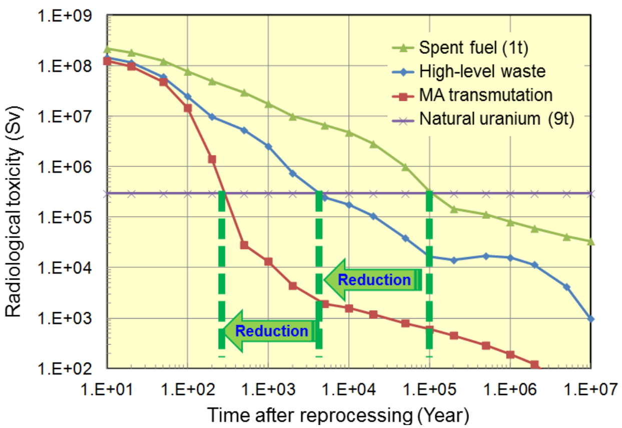
Nuclear Waste Transmutation

Composition of spent nuclear fuel

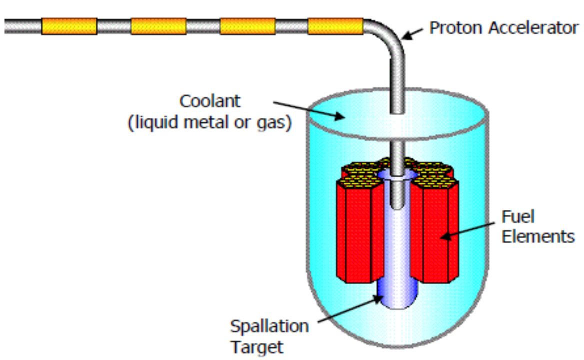


Nuclear Waste Management Strategy





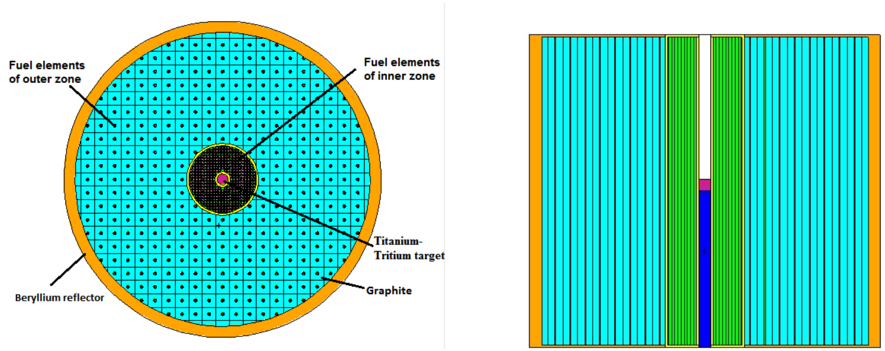
Reduction of Radiological Toxicity by P&T



Schematic picture of an accelerator-driven system (ADS) concept

Method

Monte Carlo N Particle (MCNP) model and core description

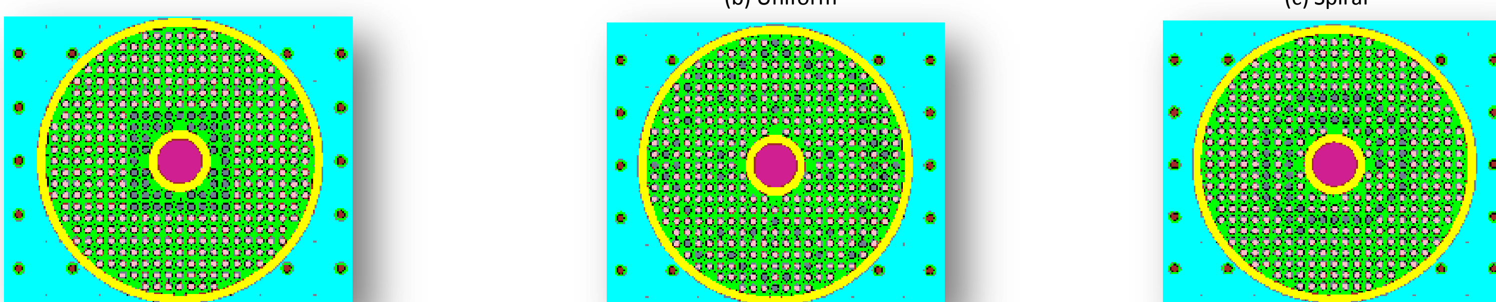


Horizontal and vertical cross-section view of MCNPX model for two regions

Table 1: ADS reactor core description for two zone model.

Description	Inner zone	Outer Zone
Core radius	15 cm	63 cm
Core height	126 cm	126 cm
No. of fuel elements	392	320
Type of fuel pins	WWER-1000	WWER-1000
Coolant	Helium/ LBE	Graphite
Fuel element pitch	1.275 cm	6 cm
Radius of pin's cladding	0.455 cm	0.455 cm
Radius of pin's fuel	0.393 cm	0.393 cm
Fuel enrichment	20%	4%
Density of the fuel	10.96 g/cm^3	10.96 g/cm^3
Fuel Cladding material	zirconium + 1% Niobium	zirconium + 1% Niobium

(a) Nonuniform (b) Uniform (c) Spiral



Three core models are considered in which selected Plutonium and minor actinide (Pu, Am, and Cm) loaded inside the inner zone

Results

➢ Subcritical multiplication parameters

By using MCNPX we calculated the fission neutrons and source neutrons for the proposed models then we calculated the subcritical multiplication parameters from the following equations:

$$M = \frac{F+S}{S}, \qquad k_s = \frac{F}{F+S}, \qquad \varphi^* = \frac{1-(1/k_{eff})}{1-(1/k_s)},$$

Where,

M - Neutron multiplication,

K_s - Subcritical multiplication factor,

Φ* - Neutron source efficiency,

F - Total fission neutron

S - Total source neutron

Table 2: Subcritical multiplication parameters and Pu/ MA Fission Rate (FR) for three core models at fixed k_{eff} = 0.97

	M		K_s		Φ*		Pu/ MA - FR	
Model	Liquid He	LBE	Liquid He	LBE	Liquid He	LBE	Liquid He	LBE
Uniform	7.47	7.82	0.866	0.872	0.200	0.211	0.622	0.653
Nonuniform	10.59	11.24	0.906	0.911	0.297	0.317	0.634	0.666
Spiral	10.08	10.69	0.901	0.906	0.281	0.300	0.619	0.652

➢ Neutron Spectrum

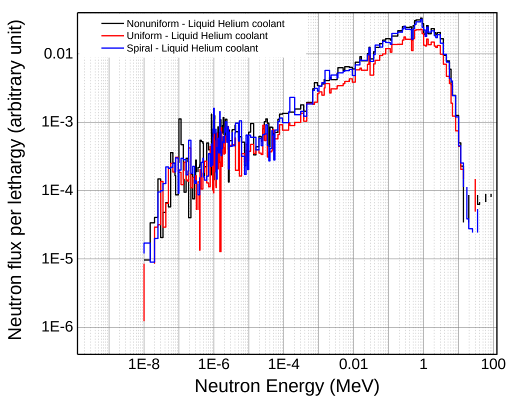


Fig. 4a: Neutron spectrum for the three models in inner zone in case of Liquid helium coolant

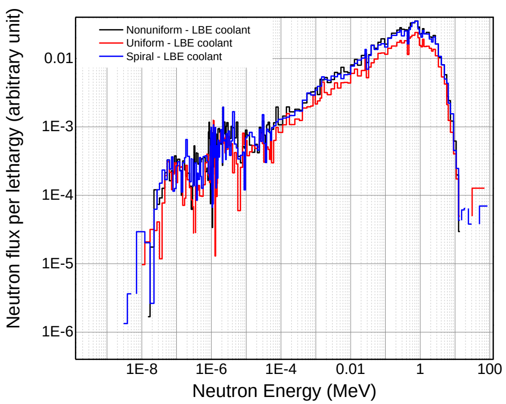


Fig. 4b: Neutron spectrum for the three models in inner zone in case of LBE coolant

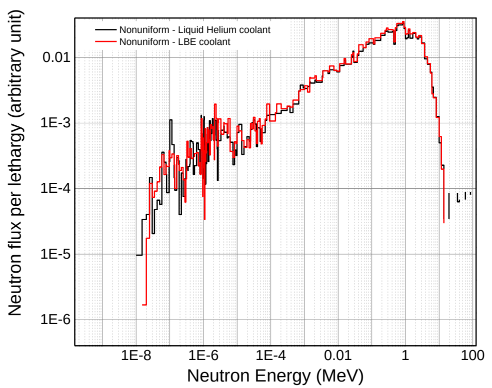


Fig. 4c: Neutron spectrum for the Nonuniform model with two coolant type (Liquid helium and LBE) in inner zone

Thank you
for your attention

For more details welcome to my poster