NE585 – Nuclear fuel cycle analysis
Project 4a – Burnup & Depletion

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Total – 400

1 Plutonium production

(100)

Solve the Pu-239 production equation. See Appendix I and Table 1 for guidance.

2 Fission product production I

(100)

Solve for fission product production for U-235 and Pu-239.

3 Burnup

(100)

Plot NvB for U-235, U-238, Pu-239, and the fission products all together. Compare to Fig. 3.29 from Benedict in Appendix II. Don't worry that the graph is B v w; the shape of the curves should be similar.

4 Fission product production II

(100)

Compute and plot the production and decay of Cs-137 and Sr-90 for an irradiation time of 24 months and a cooling time of 25 years.

Tables

Table 1. Burnup & depletion data

initial fuel mass	99.2 MTU
enrichment	3.2%
$\overline{\phi}$	$3.5 \times 10^{13}\ \frac{n}{cm^2 \cdot s}$
ϵ	1.0476
P_F	0.9889
p	0.772
σ_{25}	555.6 b
σ_{28}	2.23 b
σ_{49}	1618.2 b
σ_{40}	2616.8 b
σ_{41}	1567.3 b
σ_{42}	381 b
$\eta 25$	1.96
η_{28}	2.3432
η_{49}	1.86
η_{41}	3.06
α_{25}	0.2398
α_{28}	0.1907
α_{49}	0.5430
α_{41}	0.3765

Figures

Appendix I: Equations

$$
\begin{aligned}
\frac{dN_{49}}{d\theta} &= N_{28}^0\sigma_{28} + \kappa_{25}N_{25}\sigma_{25} - \gamma_{49}N_{49}\sigma_{49} \\
N_{49}(0) &= 0 \\
\kappa_m &= \eta_m \epsilon P_F(1-p) + \eta_m \frac{\alpha_{28}}{1+\alpha_{28}} \cdot \frac{\epsilon - 1}{\eta_{28} - 1} \\
\gamma_m &= 1 - \kappa_m \\
N_{49}(\theta) &= C_1(1 - e^{-\sigma_{49}\gamma_{49}\theta}) + C_2(e^{-\sigma_{25}\theta} - e^{-\sigma_{49}\gamma_{49}\theta}) \\
C_1 &= \frac{N_{28}^0\sigma_{28}}{\sigma_{49}\gamma_{49}} \\
C_2 &= \frac{\kappa_{25}N_{25}^0\sigma_{25}}{\sigma_{49}\gamma_{49} - \sigma_{25}}
\end{aligned}
\tag{1}
$$

$$
\begin{aligned}
\frac{dN_{25}^F}{d\theta} &= \frac{1}{1+\alpha_{25}}N_{25}\sigma_{25} \\
N_m^F(0) &= 0
\end{aligned}
\tag{2}
$$

$$
\begin{aligned}
\frac{dN_{49}^F}{d\theta} &= \frac{1}{1+\alpha_{49}}N_{49}\sigma_{49} \\
N_m^F(0) &= 0
\end{aligned}
\tag{3}
$$

$$
\begin{aligned}
B &= 9.5 \times 10^5 \cdot w \\
w &= \frac{235N_{25}^F + 238N_{28}^F + 239N_{49}^F + 241N_{41}^F}{235N_{25}^0 + 238N_{28}^0}
\end{aligned}
\tag{4}
$$

$$
\begin{aligned}
N_i(T+C) &= e^{-\lambda_i C}[Y_{25}^i N_{25}^F(T) + Y_{49}^i N_{49}^F(T)] \\
N_i(0) &= 0
\end{aligned}
\tag{5}
$$

Appendix II: Burnup graph

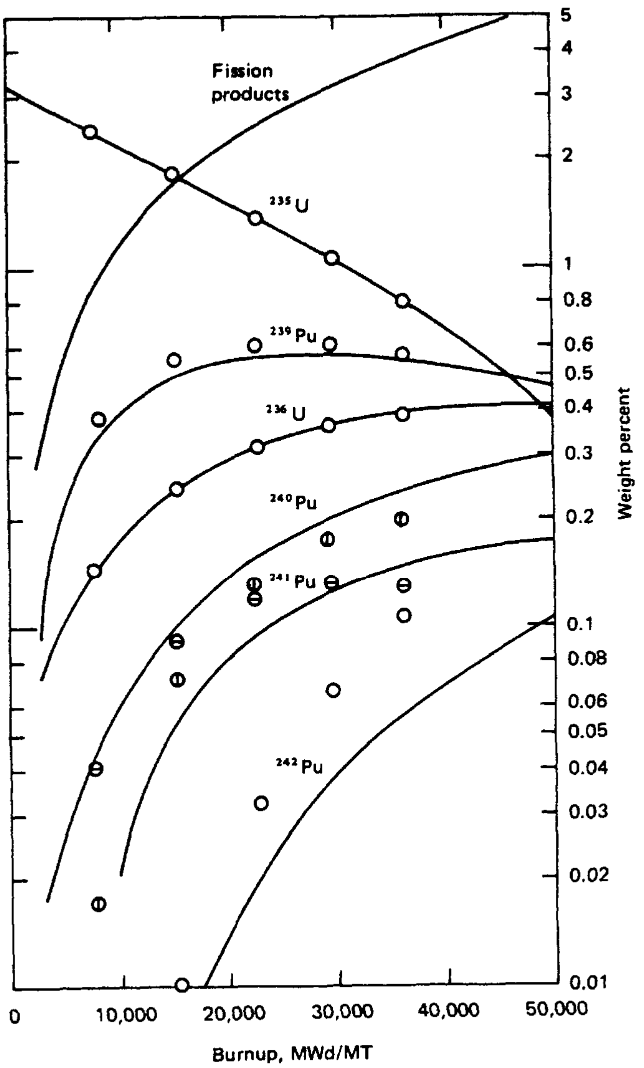

Figure 3.29 Change of nuclide concentrations in PWR with burnup. (○) Equations of this chapter; (⊖) ^{240}Pu, equations of this chapter; (⦶) ^{241}Pu, equations of this chapter; (—) computer code CELL.

concentration increases, as a result of its very high absorption cross section at resonance energies, an effect that the equations of this chapter cannot take into account.

6.7 Reactivity Changes in PWR

Despite the inability of these equations to represent accurately the concentration of higher plutonium isotopes, the reactivity-limited burnup attainable from fuel initially containing 3.2