FBR Neutronics: Breeding potential, Breeding Ratio, Breeding Gain and Doubling time

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1 Quiz

1.1 Questions

1. Determine Breeding Ratio for U-235 fuelled fast reactor. Take u = 2.6; s_f = 1.40; s_a = 1.65 and l = 0.41.

2. Is it possible to build a thermal breeder reactor with U-235 fuel? Justify your answer. Take υ = 2.42; σ_f = 586; σ_a = 681.

3. A fast breeder reactor is operating with a Breeding Ratio of 1.2. Over a period of time, the reactor had consumed 3000 kg of fissile material. Determine the quantity of additional fissile material produced by the reactor during this period.

4. A fast breeder reactor (BR = 1.3) operates at a power of 1500 MW with initial Pu-239 loading of 6000 kg. Determine the time required for this reactor to accumulate an extra 2000 kg of fuel. The absorption and fission cross section are 2.16 and 1.81 b respectively. The number of Pu-239 per unit mass is $2.52\text{x}10^{21}$ (atoms/g).

1.2 Answers

1. Using Eq. (5), $BR = \left(\frac{1.4}{1.65}2.6\right) - 1 - 0.41$

BR = 0.796

2. Using Eq. (1),

$$\eta = \frac{\sigma_f}{\sigma_a}\nu = \frac{586}{681}2.42 = 2.08$$

The reproduction factor is only slightly greater than 2. The excess (~0.08) is likely to be lost in absorption due to moderator and structural elements. Hence it is not possible to build a thermal breeder reactor with U-235.

3. By definition of Breeding Ratio (BR),

BR = number of fissile nuclei produced/number of fissile nuclei consumed

BR = mass of fissile nuclei produced/mass of fissile nuclei consumed

Therefore, Mass of fissile nuclei produced = Mass of fissile nuclei consumed * BR = 3600 kg

Additional fissile material produced = Mass of fissile nuclei produced-Mass of fissile nuclei consumed

Therefore, additional fissile material produced is <u>600</u> kg

4. P' = 1500 MW/6000 kg = 250 J/g.s

BR = 1.3;

Equation (10) may be modified for this problem by setting DT as 't' and 'M_F' as 2000 kg

$t*R_{net} = 2000*N_f$

Therefore,

$$t = \frac{2000N_f}{R_{net}} = \frac{2000N_f}{(BR-1)6000N_f\phi^{-}\sigma_a} = \frac{1}{(BR-1)3\phi^{-}\sigma_a}$$

Substituting for f^{-} as

f^{-} = P'/ ($N_f E_f s_f$)

Substituting the above in the equation for Doubling Time, we get

$$t = \frac{1}{(BR-1)3\phi^{-}\sigma_a} = \frac{N_f E_f \sigma_f}{(BR-1)3P'\sigma_a} = \frac{N_f E_f \sigma_f}{0.3*3*P'\sigma_a}$$

t = 3476 days ~ 9.5 years