Nuclear Reactor Dynamics

2006 년 2 학기

Final Examination

Dec. 14, 2006

1. Give the rationale for the following arguments and answer the associated questions. Support your answer with proper numbers, formula, or graph if necessary. (20 points)

   a. Beta-effective is larger than beta-physical in thermal reactors. What would you need to obtain a single value of beta-effective for a real reactor which has spatial distributions of everything? List three of them.

   b. The reactor flux can increase even under a subcritical condition as long as the rate of reactivity increase is sufficiently high. You may explain quantitatively with a one-group precursor formulation.

   c. In a critical reactor, a sinusoidal oscillation of reactivity with a small amplitude, say 0.1$, causes a gradual increase in the total flux level.

   d. After a positive step reactivity insertion into a critical power reactor, the core reaches to an asymptotic state with an increased power level. What are the two major parameters to determine the asymptotic power level? Give the relation for the power increment in terms of the three parameters.

2. Explain the following briefly. (20 points)

   a. Doppler broadening and the reason for increased absorption in case of resonance broadening.

   b. Static reactivity vs. dynamic reactivity

   c. Need for inverse kinetics and the essential steps involved in its usage.

3. Derive the following and answer the subsequent questions. (15 points)

   a. Prompt jump power level and the stable inverse period in one group formulation for a small reactivity insertion (use PJA). Draw the flux behavior after a step reactivity insertion with an indication of all the essential information. Show clearly the transition from the initial level to the stable behavior using two curves.

   b. $p(t)$ as a function of $\rho(t)$ which is a smoothly changing (not step) function and always smaller than 0.9$. The first factor in the answer should represent multiplication of the initial delayed neutron source.

4. Answer the following regarding analytic solution of superprompt critical transient with prompt reactivity feedback (20 points).

   a. Give the PKA equation with a suitable initial condition

   b. Find the energy produced upto the moment of the maximum power, p_m, given the step reactivity insertion $\rho_1 (> \beta)$ and γ (full-power-second coefficient), namely $I(t_m)$.

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c. Derive the expression for the maximum power.

d. Show that the total energy produced for the entire power pulse, which is supposed to end when the power reduces back to the initial level (at t_2), is merely double the energy produced till the maximum power.

e. If we define the width (τ) of the pulse such that $\tau\ p_m = I(t_2)$, show that the pulse width is given as $\frac{4\Lambda}{\rho_1 - \beta}$. Note that initial jump is negligible.

5. Determine the initial and final reactivities of a subcritial core if the relative values of the measured power signals of the initial, prompt jump and final power levels are 1, $\frac{4}{3}$, and $\frac{3}{2}$, respectively. Derive the necessary formula (10 points)

6. Suppose a one-dimensional, one-energy group, one-precursor group kinetics problem Namely, $\frac{1}{v}\frac{\partial \phi(x,t)}{\partial t} = X - \left(-D\frac{\partial^2 \phi(x,t)}{\partial x^2} + \Sigma_a \phi(x,t) \right) + Y$. Answer the following. (15 Points)

a. Define X and Y in the above equation and give the precursor balance equation in terms of $C(x,t)$ and the delayed neutron fraction.

b. Employ the implicit method to discretize the diffusion equation in time.

c. Suppose a linear variation of the flux within the time interval. Give the linear variation shape in terms of $\phi^{(l)}(x)$, $\phi^{(l-1)}(x)$ and Δt.

d. Find the analytic solution for $C(x,t)$ in terms of $\phi^{(l)}(x)$ and $\phi^{(l-1)}(x)$.

e. Explain the next step to solve the 1-D transient problem.

7. Describe the most interesting stuff you learned from this course that you think other students must know as well. (Bonus points)

수고했습니다!