commercial light-water reactors. Where power has been compared, similar good agreement has been obtained for power-producing zones. Comparisons of nodal options with detailed diffusion theory were made in one-dimensional cases prior to the two-dimensional tests.

In summary, a general response matrix approach to nodal analysis has been extended to multigroup form. The assumptions associated with the procedure have been found to be acceptable in dealing with the situations encountered in fast reactors.

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3. Double Criticality of Uniform-Power-Reflected Reactors, *Y. Ishiguro, Maria Clara F. Ierardi, Joamar R. V. Reade (IPEN-Brazil)*

It is shown that a reflected reactor of a given overall size can be critical, under the conditions of constant power density and a given fuel concentration at the core boundary, at two different core sizes. Numerical results are given for a standard model in two-group diffusion theory.

The problem of designing a flat flux and/or flat power reactor has been investigated since the earliest days of nuclear development for the purpose of optimizing reactor performance.[1,2] In the course of a study of fuel distributions under the condition of uniform power, the above-mentioned fact came to our attention. Although the analysis is trivial in the simple model we consider, we thought it is of interest to point out the existence of two solutions, since we have failed to find any reference to it.

We consider, in two-group diffusion theory, reflected reactors of a specified total thickness 2 T in slab geometry and of radius T in spherical geometry. The core is a mixture of water and ^{235}U and the reflector is pure water. We seek the critical core dimension α such that the fission rate is constant and that the uranium concentration N(x) satisfies the given constraint $N(\alpha) = N_0$. Here, x and α are the distance from the core center.

Using the same assumptions as in Ref. 3, the diffusion equations for the core are

$$D_1\nabla^2\phi_1 - \Sigma_1\phi_1 + \nu\sigma_f N(x)\phi_2 = 0$$

and

$$D_2\nabla^2\phi_2 - \Sigma_2\phi_2 + \Sigma_1\phi_1 - \sigma_a N(x)\phi_2 = 0 \quad ,$$

where D and Σ refer to water and ν, σ_f, and σ_a to ^{235}U. For the reflector we have the same equations with $N(x) = 0$. These equations are solved, under the condition

$$N(x)\phi_2(x) = 1 \quad , \quad 0 \leqslant x \leqslant \alpha$$

in an elementary way. The condition of a given uranium concentration at the core boundary

$$\phi_2(\alpha) = N_0^{-1}$$

results in the critical condition

$$af_1(\alpha) + (1 - a)\,f_2(\alpha) = 1 - \Sigma_2[N_0(\nu\sigma_f - \sigma_a)]^{-1} \quad , \qquad (1)$$

where a is a constant and, for i = 1 and 2,

$$f_i(\alpha) = \frac{\cosh(\kappa_i\alpha)\cosh(\kappa_i\beta)}{\cosh(\kappa_i T)} \quad , \quad \text{slab}$$

and

$$f_i(\alpha) = \frac{\sinh(\kappa_i\beta) + \alpha\kappa_i\cosh(\kappa_i\beta)}{\alpha\kappa_i\sinh(\kappa_i T)}\,\sinh(\kappa_i\alpha) \quad , \quad \text{sphere}$$

with $\kappa_i^2 = \Sigma_i/D_i$ and $\beta = T - \alpha$. It can easily be shown that, for sufficiently large N_0 and T, Eq. (1) has two solutions: α_1 and α_2 $(\alpha_1 < \alpha_2)$; and, for the case of slab, $\alpha_1 + \alpha_2 = T$. Note that in the infinite-reflector model the critical core size is the limiting $(T \rightarrow \infty)$ value of α_1.

The fluxes for the second (α_2) solution are higher, and the fuel concentration lower, than for the first. Thus, if power density is the only constraint, the second solution yields a higher specific power as well as a higher total power.

However, with constraints on such parameters as maximum flux and the amount of fuel, the choice is not quite obvious. We will discuss these matters at the meeting. Here we report our results for the critical core size in Table I and flux and uranium distributions in spherical reactor in Fig. 1 for the two-group model of Ref. 3.

TABLE I

Critical Core Sizes of Reflected Uniform-Power H_2O-^{235}U Reactors

N_0	T	α_1	α_2
		Slab	
0.65	30	9.86	20.14
0.70	30	7.83	22.17
0.80	30	6.13	23.87
		Sphere	
0.80	60	39.41	49.99
0.90	60	28.94	52.81
1.00	40	24.20	31.94
1.05	40	22.34	32.79

N_0 in 10^{20} cm^{-3}

T, α_1, α_2 in cm

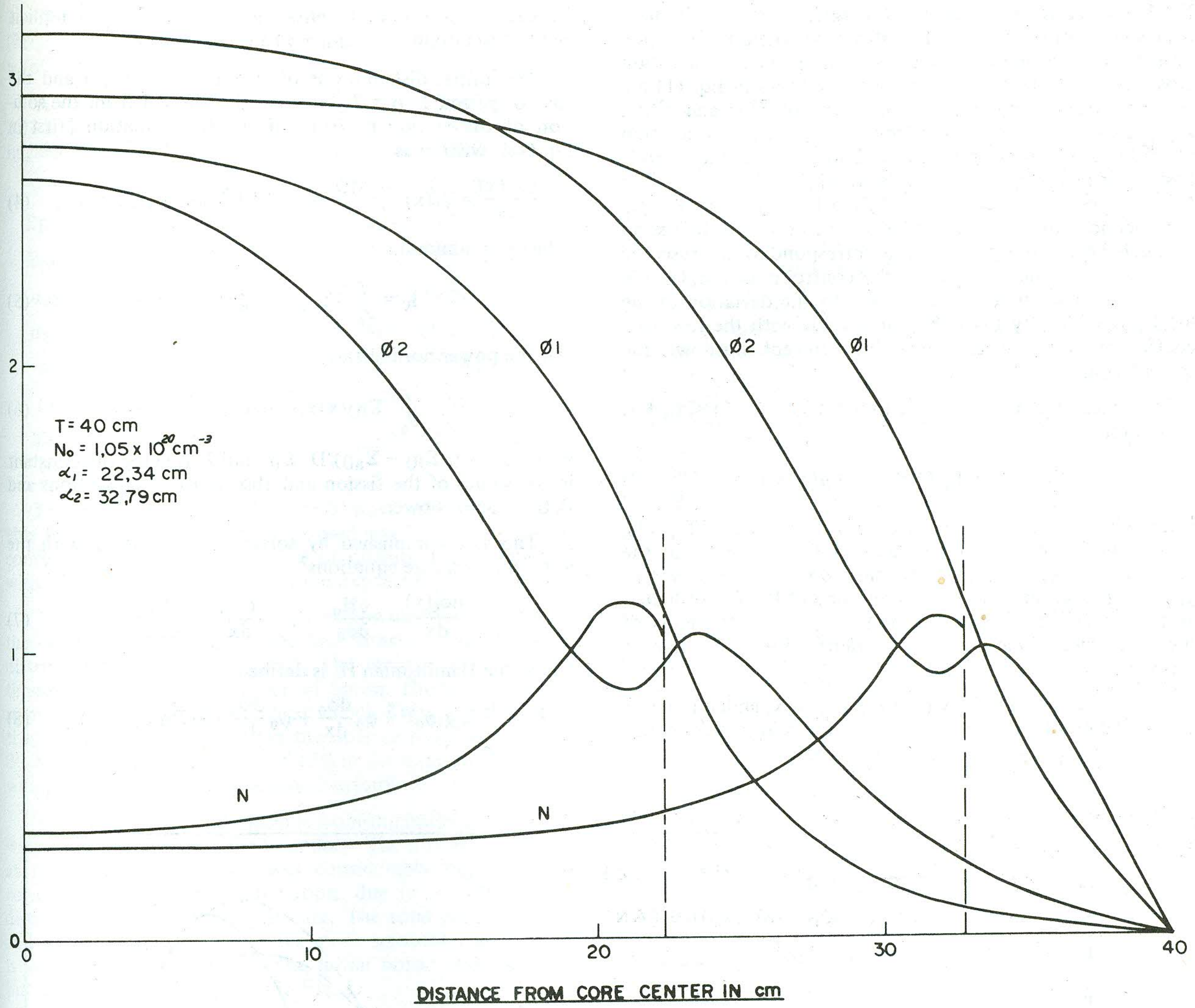

Fig. 1. Uranium concentration and fluxes in a reflected-uniform-power H_2O-^{235}U spherical reactor.

We wish to point out that in the central region of the second reactor of Fig. 1 the fuel concentration approaches the value at which the infinite multiplication factor of the mixture is unity and that in this region the fuel concentration and fluxes as well as the power density are nearly constant.

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4. On the Optimization of Control Poison, *Paulo David C. Lobo, R. Kesavan Nair (IME-Brazil)*

Depletion calculations performed with an initial control poison distribution optimized so as to minimize the neutron absorption by the control is found to produce a significant increase in the duration of operation.

The depletion calculations are usually performed with constant flux in each timestep. Westlake and Henry[1] demonstrated the advantage of simultaneous solutions of the depletion equations along with the neutron flux equation and a controller equation after linearizing them within each timestep without repeated criticality calculations for each timestep. Here, a similar approach is used, but employing a space-dependent control poison distribution. The space dependent is treated by modal expansion.

The one-group neutron flux equation in slab geometry along with the equations for the time varying parts of the macroscopic cross sections are written as

$$\frac{\partial}{\partial t}\begin{bmatrix}\phi(x,t)\\ \Sigma_f(x,t)\\ \Sigma_F(x,t)\\ \Sigma_B(x,t)\\ \Sigma_P(x,t)\\ \Sigma_c(x,t)\end{bmatrix} = \begin{bmatrix}v[\nu\Sigma_f(x,t) - \Sigma_a(x,t) - \Sigma_c(x,t) + D\nabla^2]\,\phi(x,t)\\ \sigma_{f9}[\Sigma_8^* + \beta_{ff}\Sigma_f(x,t) + \beta_{fa}\Sigma_F(x,t)]\,\phi(x,t)\\ \sigma_{a9}[\Sigma_8^* + \beta_{af}\Sigma_f(x,t) + \beta_{aa}\Sigma_F(x,t)]\,\phi(x,t)\\ -\sigma_B\Sigma_B(x,t)\phi(x,t)\\ -\sigma_P\Sigma_F(x,t)\phi(x,t)\\ \alpha[\phi(x,t)\Sigma_f(x,t) - \phi(x,0)\Sigma_f(x,0)]\end{bmatrix} , \qquad (1)$$

where the total absorption cross section $\Sigma_a(x,t)$ is given by

$$\Sigma_a(x,t) = \Sigma_N + \Sigma_F(x,t) + \Sigma_B(x,t) + \Sigma_p(x,t) \quad , \qquad (2)$$