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MASTER

MIT LMFBR BLANKET RESEARCH PROJECT

Quarterly Progress Report

January 1, 1980 - March 31, 1980

Principal Investigator

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1. General

This quarterly progress report covers work initiated, completed or underway in the period January 1, 1980 through March 31, 1980, since the prior progress report (1).

The second shipment of excess fuel back to the D.O.E. is underway using the shipping containers recently purchased by the project for this purpose. The schedule for future shipments depends to large extent on the degree to which non-project funds can be made available to cover these added expenses (2).

During FY 1980 work is being carried out on the following subtasks:

- a) evaluation of the thermal/hydraulic/mechanical consequences of enhanced fertile and fissile capture rates at interfaces,
- b) development of simpler ways to estimate interface capture rate enhancement
- c) particularization of the breed/burn internal/external blanket management scheme
- d) participation in the Large Core Code Evaluation Working Group (LCCEWG) program: the third Benchmark Problem is now being worked on (3)

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- (1) MIT LMFBR Blanket Research Project
Quarterly Progress Report, Oct. 1, 1979 - December 31, 1979
COO-2250-41, March 6, 1980.
 - (2) Ref. letters M. Driscoll (MIT) to P. Hemmig (DOE) dated 2/20/80 and J. de Vries Gwinn (MIT) to R. Nack (DOE-Chicago) dated 5/12/80.
 - (3) N.C. Horning, M.B. Parker and R.D. Omberg, Proposed Third Benchmark Problem for the Large Core Code Evaluation Working Group (Revised), HEDL, February 1980.

2. Interfacial Heterogeneity

In the last quarterly report (1), the interface reaction rate spiking at a plane interface was discussed. Similar considerations can be used to develop relations applicable to inserts in a larger zone (4), as follows.

Advanced FBR concepts are now being considered which resort to the use of dispersed zones of fertile or moderator materials, ranging from pin to assembly size, inside or among fissile-fueled assemblies in the core zone (or fertile-fueled assemblies in the radial or internal blankets).

Since most calculations are carried out using infinite medium self shielding, it is essential that the additional resonance reaction rate spike be estimated near the interface.

Consider a cylindricized supercell consisting of two zones: one is "fuel," which contains the resonance absorber of interest and one is "non-fuel," which does not contain the absorber of concern (e.g. a thorium or moderator zone in a Pu/U-238 core).

At the interface we will assume that the current J^+ arrives with a fully-developed set of resonance-induced flux depressions, as does the uncollided part of J^- . The collided fraction of J^- is assumed to have these features completely erased by a single scattering collision in the moderator zone. Thus we may associate the fully shielded σ_1 with J^+ and the uncollided part of J^- , and the infinitely dilute σ_∞ with the collided part of J^- . The interface cross section σ is then given by:

(4) Analysis of the Fast Mixed Spectrum Reactor, MIT-FMSR-3, April 4, 1980.

$$\sigma = \frac{J^+ \sigma_1 + (1-C)J^- \sigma_1 + C J^- \sigma_\infty}{J^+ + J^-} \quad (1)$$

where we have ignored any differences in the angular dependence of J^- and its collided component, and where C is the collision probability.

We assume the region is sufficiently small that the flux and currents are related by

$$J^+ = J^- = \frac{\phi}{4} \quad (2)$$

Equation (1) becomes

$$\left(\frac{\sigma}{\sigma_1} \right) = 1 + \frac{C}{2} \left[\frac{\sigma_\infty - \sigma_1}{\sigma_1} \right] \quad (3)$$

As a check we note that if $C = 0$ (no interactions in the NF-zone) then the fuel medium cross section applies ($\sigma/\sigma_1 = 1$), while if $C = 1$ (a thick moderator zone) σ is just the average of the values applicable deep inside the media on either side of the interface.

To compute C we may use Wigner's approximation, in which case

$$C = \frac{\tau}{1 + \tau} \quad (4)$$

where τ is the optical thickness for scattering in the moderator insert. For a cylinder of diameter d

$$\tau = \int_s d \equiv d/\lambda_s \quad (5)$$

For example, an assembly-sized insert of a beryllium would have $\tau \approx 8$, hence $C \approx 0.9$. Thus if σ_∞ were substantially larger than σ_1 an appreciable interface spike could result.

Fortunately the presence of the surrounding fuel helps keep the ambient spectrum sufficiently hard for most moderators that σ_∞ can be kept adequately small for small moderator inserts. For large inserts (or in the case of hydrogen), σ_∞ may be greatly enhanced.

Calculations have been made for a configuration consisting of an isolated beryllium assembly surrounded by fuel assemblies. Both σ_1 and σ_∞ were collapsed over the beryllium zone spectrum. The following results were obtained:

	<u>σ_1</u>	<u>σ_∞</u>	<u>$(\frac{\sigma}{\sigma_1})$</u>
U-238 Capture	0.7326	1.936	1.74
Pu-239 Fission	62.46	79.67	1.12

As can be seen, appreciable interface peaking can be experienced near large moderator inserts. Smaller inserts, or inserts which are not highly moderating, will exhibit considerably smaller effects. In last quarter's report, for example, the corresponding peaking factors at a core/thick internal blanket interface were only 1.08 for U-238 and 1.01 for Pu-239.

3. Internally Heterogeneous Core and Blanket Assemblies:
Thermal and Mechanical Consequences

Using the LCCEWG Third Benchmark Problem as a reference, 271-pin core and 127 pin blanket assemblies have been defined for use in thermal hydraulic analyses.

After a literature search, the COBRA-IV-I program was selected as the means to carry out state-of-the-art computations. A sample problem has been run satisfactorily and the core assembly is now being modelled. The objective of these initial studies will be to determine the extent to which peripheral pins are overcooled: this will determine the tolerable margin for interfacial reaction rate peaking.

We will also evaluate simpler approaches which can be used for scoping studies: for example, using isolated subchannels with or without a posteriori corrections for mixing.

4. The Breed/Burn Core Design

In parallel with the work being done to model an entire core (using 30° symmetry) for the third LCCEWG Benchmark problem, we are also modelling internally heterogeneous assemblies, which are a not uncommon feature of advanced FBR core designs such as the Breed/Burn configuration examined at MIT (5) and the FMSR at BNL.

Figure 1 shows a number of variations of interest. During the coming quarter we will be doing 2DB snapshot and burnup analyses of configurations of this genre. Local power peaking and the ability to sustain a high reactivity value during burnup will be of particular interest. We will also evaluate the susceptibility of otherwise attractive arrangements to interface reaction rate spiking using the approximate methods outlined in Section (2).

A thesis prospectus in this area by M. Plys is appended.

(5) B. Atefi, M.J. Driscoll, and D.D. Lanning,
"An Evaluation of the Breed/Burn Fast Reactor Concept,"
COO-2250-40, MITNE-229, December 1979.

FIG 1

INTERNALLY HETEROGENEOUS
ASSEMBLY CONFIGURATIONS

LARGE MODERATOR OR BLANKET PIN

INSERT IN 271 PIN CORE ASSEMBLY

REFERENCE 271 PIN CORE ASSEMBLY

WITH MODERATOR PINS

60° SECTOR

 $\frac{1}{6}$ ASSEMBLY

REFERENCE 127 PIN
 BLANKET ASSEMBLY
 LCCEWG 3RD BENCHMARK PROBLEM

60° SECTOR

 $\frac{1}{6}$ ASSEMBLY

BLANKET ASSEMBLY WITH
 MODERATOR INSERT

5. Administrative Matters

The monthly financial statement for March is attached:
it also includes FY totals to date.

As of March 31, 1980 the project staff was as follows:

Staff

M.J. Driscoll, Principal Investigator
R. Morton, Computer Operations Assistant
A. Holman, Senior Staff Assistant

Students

D. Lancaster, Research Assistant
A. Kamal, Research Assistant
S. Ahmad, SM thesis student