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Neutron Behavior of Coupled Rover Cores

R. L. Seale and C. G. Chezem

The neutronic behavior of an array of clustered rocket reactor cores has been investigated. The interaction between the cores of an array is described by a coupling coefficient (α) and lag time (τ) characteristic of the interchange of neutrons between cores. Expressions for the transfer function of each core in an array due to rod oscillation in one core are derived (1).

The coupling parameters for Kiwi-B-4 type propulsion reactor cores are evaluated (2) using a technique based on perturbation theory (3). Assuming neutron exchange between cores, the neutron population (n/l) in a core adjacent to another core in which the neutron population is $(\frac{n}{l})'$ is given by:

$$(\frac{n}{l}) = k(\frac{n}{l}) + \alpha(\frac{n}{l})',$$

where k is the multiplication factor in the unprimed core. This equation defines the coupling coefficient α . It is shown that:

$$\alpha = (1-k) \nu G \sum_{\text{g-groups}} \mathcal{L}_g^* \mathcal{L}_g'$$

where ν is the number of neutrons produced per fission,

- G is an attenuation factor,
- $\mathcal{L}_g'$ is the g -th group neutron leakage per neutron produced in the primed core, and
- $\mathcal{L}_g^*$ is the g -th group adjoint neutron leakage if a distributed source equal to the fission cross-section is placed in the unprimed core.

The weighted lag time τ is represented by:

$$\tau = D \frac{\sum_{g\text{-groups}} \mathcal{L}_g' \mathcal{L}_g^* / V_g}{\sum_{g\text{-groups}} \mathcal{L}_g' \mathcal{L}_g^*}$$

where D is the core separation distance, and

V_g is the neutron velocity in the g -th group.

Static and kinetic behavior of a square array of four coupled Kiwi-B4 type cores has been analyzed.

The static analysis includes the effect of unequal steady-state multiplication on relative flux levels between cores. The relative power (flux) level in a "shutdown" core due to the neutron leakage from the other cores is found to be 4% if the shutdown margin is -5.

The kinetic analysis includes Bode plots of transfer function amplitude and phase versus rod oscillation frequency for each core in the clustered array. Typical amplitude results are shown in Figure 1. (The rod oscillates in core 1, core 3 is

Figure 1. Transfer Function Amplitude versus Frequency
 for a Square Array of Rover Cores.

diagonally across from core 1.) Nyquist plots are presented which indicate system stability. The results of including temperature-reactivity effects in the analysis will also be shown.

No instabilities are encountered for values of parameters representative of the Kiwi-B-4 system.

- (1) Seale, R. L., "Coupled Core Reactors", Los Alamos Scientific Laboratory Report LAMS-2967, February, 1964.
- (2) Seale, R. L., "Investigation of Coupled Rover Cores", Los Alamos Scientific Laboratory Report LAMS-2968, February, 1964.
- (3) Hansen, G. E., and Sandmeier, H. A., "Neutron Penetration Factors Obtained by Using Adjoint Transport Calculations", Letter to editor Nuclear Science and Engineering, submitted June, 1964.