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# NEUTRON AND GAMMA TRANSPORT EFFECTS IN HETEROGENEOUS CORE DESIGNS

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# NEUTRON AND GAMMA TRANSPORT EFFECTS IN HETEROGENEOUS CORE DESIGNS*

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The use of diffusion theory for the prediction of power production near a reactor core-blanket interface and the assumption that gammas are absorbed in situ can lead to substantial errors. This is primarily due to the breakdown of Fick's law for neutron diffusion near the core-blanket boundary, and the gamma leakage from the core into the blanket. These considerations are more pronounced in a situation where a large number of internal blanket assemblies are present, such as in the large heterogeneous core designs. This paper examines the power distribution from both fission and gamma heating in a large heterogeneous LMFBR with 3 core zones separated by 2 internal blanket zones. Comparisons are made between diffusion and transport theory for neutronics calculations, and between in-situ absorption and rigorous transport theory calculation for gamma heating.

The reactor studied is a 3000 MWt $UO_2$-fueled heterogeneous LMFBR at beginning-of-life conditions, details of which are given in Reference 1. For the nuclear analysis, both diffusion theory and discrete ordinate transport ($S_4$ with $P_o$ Legendre expansion) use the same cross section set

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with 21 neutron energy groups. For the gamma heating evaluation, results from both in-situ absorption and discrete ordinate transport ($S_4$ with $P_3$ Legendre expansion) are based on 20 gamma energy groups. These results are given in Fig. 1.

Gamma heating typically accounts for about 10% of power in the core zones, and as much as 34% of power in the internal and radial blankets at BOL. The assumption of in-situ gamma absorption leads to an under-prediction of gamma heating rate from 15 to 40% in the internal and radial blankets near the core-blanket interface, with the largest underprediction occurring at the outermost radial blanket pins. This can be observed in the lower curves in Fig. 1.

Relative to the $S_4$ calculation, diffusion theory underpredicts fission power in the first 2 inner cores and in the first 2 internal blanket regions; and overpredicts fission power in the outermost core. The underpredictions are approximately 3 to 5% in the inner cores, 2 to 15% in the internal blankets; the overprediction in the outermost core is near 2%.

The combined effects of diffusion theory and in-situ gamma absorption, as seen in the upper curves in Fig. 1, are (a)underprediction of power by 3 to 5% in the inner cores, overprediction of power by 1 to 2% in the outermost core, (b)underprediction of power in the internal and radial blankets near the core-blanket interface in the range of 22 to 35%. The interface region thickness is approximately 1/2 the pitch of a blanket assembly.

These results indicate that an orificing scheme should take into account the larger rate of power production in the internal and radial blankets near the core-blanket interface due to neutron transport and gamma heating effects. The impact of the discrepancies described above will be reduced at EOL, due to the increase of fission power and the relative constancy of gamma heating. For example, the peak linear heat ratings in the internal and radial blankets are near 4 kW/ft at BOL, increasing to approximately 11 kW/ft at EOL. With the peak gamma heating rate staying close to 1.4 kW/ft throughout the blanket assembly's lifetime, the maximum discrepancy of 40% between in-situ and transport calculation for gamma heating represents a correction of 0.56 kW/ft, accounting for a 14% correction of total power at BOL, but less than 6% at EOL.

1. W. P. Barthold, J. Beitel, E. Khan, and C. Tzanos, "Potential and Limitation of the Heterogeneous Reactor Concept," submitted for presentation at the 1977 ANS Annual Meeting, New York, June 12-17, 1977.

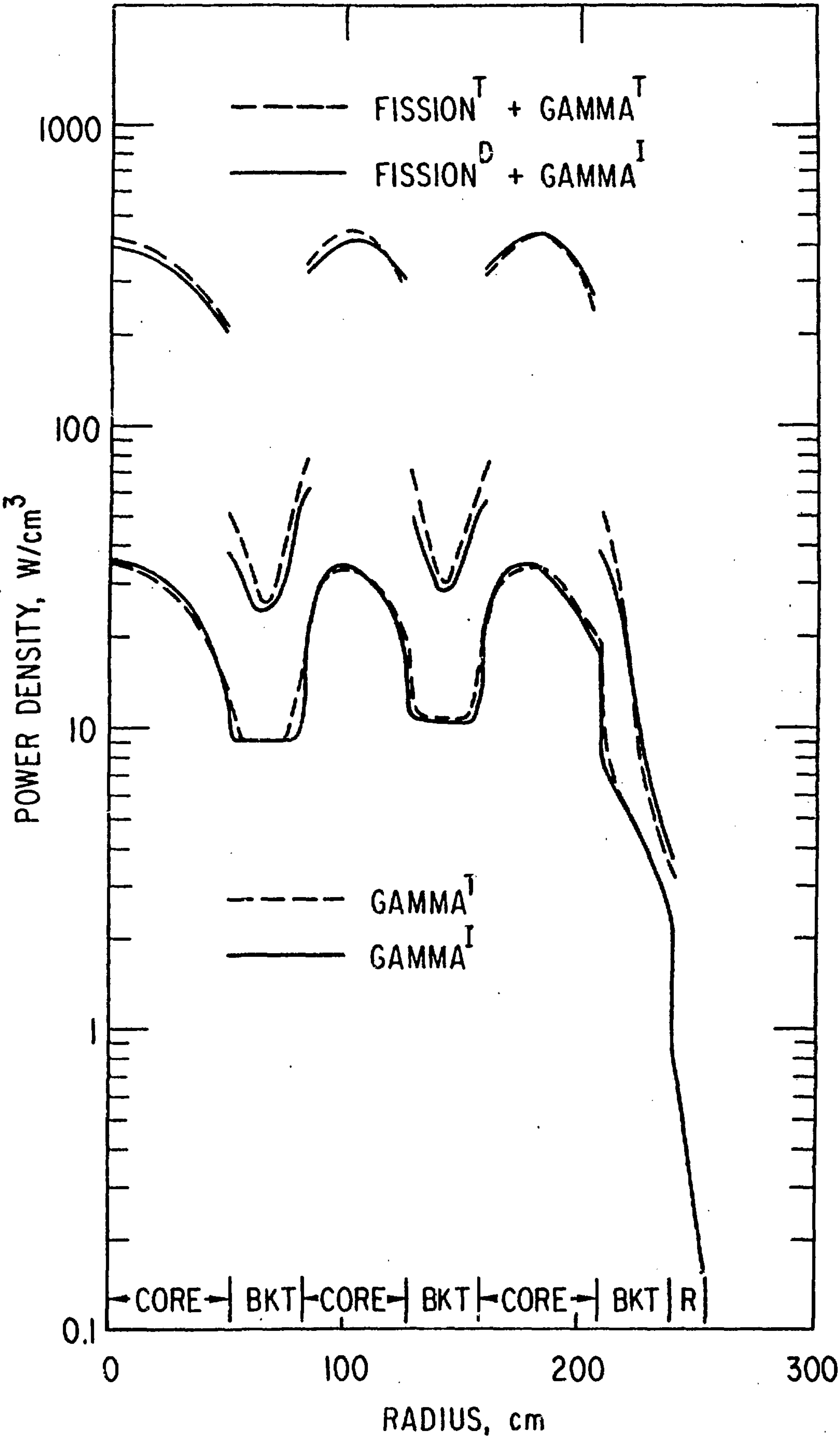


Fig. 1. Mid-Plane Power Densities of the Heterogeneous Core. D=Diffusion, T=Transport, I=In-Situ Absorption.