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TITLE

FLUX DISTRIBUTION IN URANIUM SLUG IN THE
PRESENCE OF A BORON CARBIDE SPLINE

AUTHOR

NOV 23 1992

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FLUX DISTRIBUTION IN URANIUM SLUG
IN THE PRESENCE OF A BORON CARBIDE SPLINE

By Authority of DOC

May 1973

By P.M. Eick 10-28-92
SH. Will 10-28-92

INTRODUCTION

A potentially attractive method of achieving additional flexible reactivity control in the production reactors is that of introducing neutron absorbers contained in thin flexible metal strips between the slug and process tube wall. It is possible that the neutron absorbing splines could be used to provide additional flexible control during operation as well as temporary control during outages. The application of splines during reactor operation is contingent upon the neutron absorber creating tolerable thermal gradients such that excessive slug rupture rates will not ensue. This report describes measurements of the distribution of power in a uranium slug immediately adjacent to a prototype control spline. Measurements were made in the metal test stringer of the Hanford Test Pile.

SUMMARY

The distribution of power density in a slug is taken to be proportional to the distribution of thermal neutron density. Thermal neutron density as a function of slug radius was determined by placing approximately 30 copper detectors at appropriate slug radii and observing the induced radioactivity with a gamma ray scintillation spectrometer. The neutron distribution in a typical slug irradiated in an unperturbed flux is shown in Figure 1, while Figure 2 gives a contour plot of lines of equal flux through a slug irradiated immediately adjacent to a neutron absorbing spline.

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In the case of the slug irradiated adjacent to a neutron absorbing spline, the flux was found to increase outward from the center at approximately the same rate at all radial angles in the top half of the slug and to decrease to a minimum on the lowest point on the slug's surface, that is, the point on the surface in contact with spline. The values of flux at the surface of the slug, relative to unity at the geometric center, were 1.70 at the top, 1.65 at the sides, and 0.77 at the point of contact with the spline. The flux at the top of the slug was reduced 8% below that which would be observed had the spline not been present.

These power distributions are not particularly meaningful in themselves, but are intended to serve as the basis for calculations of temperature distributions and associated thermally induced stresses.

DISCUSSION

A short length of canned natural uranium slug column was irradiated in the Hanford Test Pile in a dry process tube assembly with the boron carbide spline inserted between the process tube ribs and hence, between the process tube and slug can walls. The spline which was used was approximately 30 inches long, 0.44 inches wide and 0.05 inches thick. It was curved to approximately fit the contour of the process tube which resulted in the surface of the spline being removed approximately 0.03 inches from the surface of the slug can; hence the measured neutron distributions would probably be slightly different in a water cooled assembly.

The central slug in the slug column was composed of a uranium wafer 1/4 inch in length sandwiched between two longer uranium pieces to composite an 8 inch slug. About 30 copper pin detectors were inserted in 1/16 inch O.D. holes distributed appropriately throughout the uranium wafer. Additional copper detectors were placed on the slug surface. The reciprocal diffusion length λ for neutrons in copper is essentially the same as that in natural uranium, consequently, the perturbation caused by the presence of the relatively large amount of copper is believed to be small. The activities of the copper pins were determined by means of a gamma ray scintillation spectrometer following the irradiation. The data were then normalized to yield the ratio of the activity of each detector to that of the detector located at the geometrical center of the slug. The contour plots of the relative flux densities, as a function of position in the slug as shown in Figure 2, are drawn assuming that the neutron density is symmetric about the plane from the center line of the spline through the center line of the slug. This assumption was supported by the experimental values which were available. The volume average value of the flux was not calculated although it can readily be calculated from the available data.

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Fig.1

Equal Flux Contours in Natural
Uranium Slug - Unperturbed

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Scale :: 5:1
Slug radius = 1.692 cm
Flux values relative
to 1 at center

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Fig.2

Equal Flux Contours in Natural
Uranium Slug- Perturbed by
Boron Carbide Spline in Bottom
of Dry Process Tube

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Scale:: 5:1
Slug radius = 1.692 cm
Flux values relative
to 1 at center

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